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CONTENTS OF VOLUME XXX.

NUMBER CLXXXI.

NUMBER CLXXXII.

SCIENTIFIC INTELLIGENCE.

NUMBER CLXXXIII.

SCIENTIFIC INTELLIGENCE.

NUMBER CLXXXIV.

NUMBER CLXXXV.

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ART. I.—*Observations on Invisible Heat-Spectra and the recognition of hitherto unmeasured Wave-lengths, made at the Allegheny Observatory*;* by S. P. LANGLEY, Allegheny, Pa. With Plates I to IV.

IT is known to all, that the surface temperature of this planet depends upon the properties of radiant heat and the relation to them of the action of its atmosphere. It has been usual to compare this action to that of the glass cover of a hot-bed; for glass, it is also well known, grows opaque to dark heat, and continuously so, as its wave-length increases, thus letting the solar light-heat pass freely through it to the soil, while it is comparatively impervious to the dark heat returned from the latter; but this analogy must not be interpreted too literally. Whether the atmosphere is pervious to the soil's heat we do not here discuss, but it has of late† been shown that the air does not behave otherwise like glass as it was supposed to do, but except for the absorption bands, grows—not more opaque—but more transmissible, to *solar* heat, up to its greatest observed wave-length, and that hence our views of the nature of the yet uncomprehended heat-storing action which maintains organic life on the earth must be modified. The little that the spectroscope tells us about the atmospheres of other planets, leads us to think that we can best understand their relations to solar energy by studying the atmosphere of our own; for our non-comprehension of these relations is largely due to our

* Read before the American Association for the Advancement of Science, at Ann Arbor.

† See this Journal, March, 1883, Professional Papers of U. S. Signal Service, No. 15, Expedition to Mount Whitney.

ignorance of certain physical data which have never yet been obtained.

While the general question for the physical astronomer then, is "What kind of transformation does the solar energy suffer at the surface of any planet?" we here seek a reply to the simpler preliminary one, "What are the wave-lengths of heat from non-luminous sources, such as the soil of this planet?" a question which has never been answered, because there have been no means of recognizing this heat when drawn out into a spectrum; indeed we so habitually associate the idea of a spectrum with that of light, that there is a certain strangeness, at first in the idea even, of a "spectrum" formed by a cold body like, for instance, ice. Yet the ice surface must not only be capable of radiating heat to a still colder body, but according to our present conceptions of radiant energy, be capable of giving a spectrum, whether we can recognize it or not. It is the object of the present paper to describe the actual formation of such spectra, and the recognition of their heat in approximate terms of wave-lengths.

To distinguish between these new regions of research and the older ones, let us briefly summarize our actual information about wave-lengths, since on the latter the whole question largely turns, and each extension of it, we may agree, is a step toward an interpretation of everything about the constitution of the universe which radiant energy may have to tell us. Thus there is no exact relation known between the periods of vibration of certain molecules in the sun and the angles through which the rays announcing them, are refracted by a prism, while the wave-lengths of these rays, if known, are capable of giving us quite other intelligence.

Yet our knowledge even of the wave-lengths of light is comparatively recent, since it was only at the beginning of this century that the labors of Thomas Young brought the undulatory theory itself from the disfavor in which it had lain, and the memoirs in which Fraunhofer gave the first relatively full and accurate measures of the wave-lengths of light date no farther back than 1814.

The measures of Newton, interpreted in terms of the present theory, gave the length of the extreme violet waves at $\frac{167}{10,000,000}$ of an inch, and of the extreme red at $\frac{266}{10,000,000}$, or in millimeters $0{\cdot}00042^{mm}$ and $0{\cdot}00067^{mm}$ respectively, numbers nearly corresponding with the lines H and B, while Fraunhofer's own values are comprised between $0{\cdot}00036^{mm}$ and $0{\cdot}00075^{mm}$. More recently the range of vision has been still more extended, by the use of the fluorescent eyepiece of Soret, while by the aid of photography and the employment of quartz trains, solar radiations of a wave-length of about $0{\cdot}29\,\mu$ have been observed,*

* ($1{\cdot}0\,\mu = 0{\cdot}001^{mm}$).

and rays whose wave-length is as little as 0·185 μ have, it is said, been observed from the induction spark.

Our atmosphere cuts off the ultra violet rays of a length less than about 0·29 μ, while I have found it not very difficult to see, below Fraunhofer's great A, lines whose wave-length is about 0·81 μ. The extreme range of the normal eye then, is from about 0·00036 to 0·00081^{mm}, or a little over one octave, though the statement that the range of the eye is less than one octave is still commonly made.

Fraunhofer's first measures were made with a literal grating composed of parallel strands of wire, while the successive labors of Nobert, Rutherfurd and Rowland have placed in the hands of physicists instruments of constantly increasing power, which have finally reached what seems nearly theoretical perfection at the hands of the two latter. It is with the now so well known gratings of Professor Rowland that the direct measures of wave-lengths in the solar heat spectrum I have already made public* have been chiefly executed.

In Plate I we have a necessarily condensed representation of the whole spectrum, visible and invisible, on the normal scale, the distances being proportional to the wave lengths observed. The inferior limit being 0, we have at (a) the number 0·18 μ (eighteen one-hundred thousandths of a millimeter), which represents the shortest measured in the electric spark from aluminum. Next near 0·29 μ (b) we have, according to M. Cornu, the shortest solar ray which penetrates our atmosphere; near 0·35 μ (c), in the ultra violet, is the shortest wave which can be seen by the naked eye, and nearly the shortest which can pass through glass, while near 0·81 μ (d) in the extreme red, is nearly the longest which the eye can observe. The entire visible spectrum on the normal scale is, it will be seen, insignificant in comparison with that great infra-red region which is so important to us, and of which we know so very little. It has been known since the time of the first Herschel that heat rays existed below the range of vision, but of their wave-lengths nearly nothing has, till lately, been ascertained, partly for want of sufficiently delicate heat-recognizing apparatus, and still more from the fact that it is difficult to use the grating here, owing to the overlapping spectra, and to the consequent necessity we have till lately been under, of separating these rays only by the prism, which gives no measure of their wave-lengths. Physicists have accordingly attempted to find these, by observing what deviations correspond to known wave-lengths in the visible portion, and by trying to determi e, from theoretical considerations, what relations should obtain in

* Comptes Rendus, Sept. 11, 1882. National Academy of Science, 1883. This Journal, March, 1884.

the infra-red, but the various formulæ by which these suppose relations have been expressed have not till lately been tested The difficulty has been partly overcome in the last few years by the application of the linear bolometer to the spectrum formed by the concave gratings with which Professor Rowlanc has furnished us; the deviations of the heat rays having first been observed and the principal lines of the infra-red region mapped by the joint use of the bolometer and a flint glass prism, in 1881. It will be remembered that one of the best known formulæ on which physicists have till lately relied for determining the relations of wave-lengths to deviations was Cauchy's; that this set an absolute limit to the wave-length which any prism could under any circumstances discriminate and that this supposed extreme wave-length was somewhere between 10,000 and 15,000 on Ångström's scale. Besides thi theoretical limit, it was supposed that glass absorbed darl heat to such an extent, that the longer solar heat waves woul be stopped in the substance of the prism, even were there n other obstacle.

In 1881, however, we found at Allegheny by actual tria that heat waves whose wave-length was far in excess of th theoretical limit, passed through a flint glass prism, so that it wa ascertained both that this supposed limit did not exist, and th common glass was comparatively diathermanous to all the dar heat which comes to us from the sun. By means of a glas prism and the bolometer, we were thus able to pursue ou researches and map the infra-red or invisible solar spectrum t a point where it actually came to an end. What the wav length of this point was we could not tell, for it lay entirel outside of what theory had till then pronounced possible.

Next, using the grating, we have at Allegheny determine the wave-lengths of most of the newly discovered solar he region, by direct observation, and shown that it extended t the unanticipated length of $2^{\mu}\cdot7$ (*e*, Plate I) (i. e., 27,000 o Ångstrom's scale.) I cite these facts, which have already bee published, to bring us up to the point where the preser researches begin.

The question now arises, "Does this ultimate observabl wave-length of solar heat of $2^{\mu}\cdot7$, which our atmosphere trans mits, correspond to the lowest which can be obtained from an terrestrial source, or are the wave-lengths emitted from ou planet toward space, even greater, and conceivably such tha our atmosphere is nearly athermanous to them?" To answe this it becomes necessary to do what I think has not bee attempted before: to take a source of very low temperature comparable to that of the soil, and not only to measure its ex tremely feeble invisible heat, but to draw this out into a spec

trum by means of a prism or grating, and to determine the indices of refraction of its prominent parts, and by inference, their wave-lengths. We have now been engaged on this research at Allegheny at intervals for two years, a time which will not appear extravagant to one acquainted with its extreme difficulties. Not to dwell on these in detail, I will mention, only, that the grating can not well be used on account of its overlapping spectra, if for no other reason, and that the most transparent glass, which we have found to be comparatively diathermanous to dark solar heat, turns out to be almost absolutely athermanous to the heat from a surface at the temperature of boiling water.

Glass being useless here, almost the only material of which we can form our prism is rock-salt, and we must have not only an entire train of lenses (both collimating and observing) of salt, as well as the prism, but the pieces must be of exceptional size, purity and perfection of figure, to contend with these special difficulties, and they must be maintained in condition, in spite of the incessant deterioration of this substance. Finally, as we wish to determine wave-lengths, these measures must be very accurate, and the prism be capable of giving fixed points of reference like the visible Fraunhofer lines. The prism we are now using was made by Mr. J. A. Brashear of Pittsburgh, and when freshly polished, gives a spectrum not only filled with hundreds of Fraunhofer lines, but which shows distinctly the nickel lines between the D's, and is probably the finest one ever produced from this material.

Such measures on the collective heat of black bodies as those of Melloni and Tyndall have been made on large radiating surfaces, like those of the Leslie cube, but in order to form a spectrum, of this as of any other source, we must, of course, take only such a limited fraction of the side of the cube as is represented by a narrow spectroscope slit; so that both from its minute amount and feeble intensity (even if we can pass it through a prism, to form a spectrum), it is absolutely inappreciable, in anything like homogeneous portions, to the most delicate thermopile, and difficult of attack even by the bolometer.

We have employed, as radiating surfaces, Leslie cubes covered with lampblack and filled with boiling water or aniline, the former giving a radiating surface of temperature of 100° C., the latter one of 178° C. and also cubes filled with freezing mixtures, with the latter of which Mr. F. W. Very, of this observatory, conducted in the cold days of last March one series of measures in which the radiator was the bolometer itself, at a temperature of −2° C. and the source radiated to, a vessel filled with a mixture of salt and snow at a temperature of −20° C., thus determining the distribution of energy in the *spec-*

trum of a surface below the freezing point of water. Th Leslie cube used in these experiments was filled either with freezing mixture, or with water kept gently boiling by a Bur sen burner underneath; or again, when measurements from source at an exactly determinable higher temperature were de sired, with aniline, which has a boiling point of about 178° C A condensing apparatus connected with the cube, in the latte case prevented the escape of the aniline vapor. It was als found possible to keep the cube at any intermediate tempera ture within sufficiently narrow limits by properly adjustin the flame.

The apparatus is shown in Plate 2. Between the blackened side of the Leslie cube C and the spectrometer slit S, were in terposed a large pasteboard screen (*a*) and a flat copper vesse (*b*) filled with broken ice, both pierced with apertures slightl larger than the slit, to allow the passage of the rays, and th exposures were made by withdrawing a third hollow screen (c made of copper and filled with ice, which cut off the radiatio of the cube from the slit when it was in place.

The train for forming the spectrum upon the bolometer fac consisted of two rock-salt lenses L, L, and the rock-salt prism E Each lens is 75^{mm} in diameter and 350^{mm} focus for visible rays For the infra-red rays measured on, the focus is from one to tw centimeters greater than this. The prism is made from an ur usually perfect piece of rock-salt, and is 64^{mm} on a side. It constants having been fully given in this Journal for Decembe we will only repeat here for convenience that its refractin angle is 59° 57′ 54″, and that the indices of refraction for th Fraunhofer lines H_2, b_1, A, are 1·56920, 1·54975, 1·53670, re spectively, while that of *Ω*, the farthest considerable absorptio band in the infra-red of the solar heat spectrum is 1·5268, co responding to a known wave-length* of 1$^{\mu}$·82. With this trai composed entirely of rock-salt, and an ordinary eye-piece, th Fraunhofer lines are very distinctly visible in either sunligl or moonlight. The lenses, prism, slit and other parts of th train were mounted upon the large spectrometer (described i this Journal, xxv, 1883, and in the Mt. Whitney Repo Chapter xi).

To illustrate the use of the apparatus, we give below in d tail the observations of March 20, 1885, for determining th form of the energy curve in the spectrum of a Leslie cube 178° C. The temperature of the room was −7° C., so th the excess of the temperature of the cube over that of th room was 185° C.

The reading of the circle was made 0° 0′ 0″ when the spe trometer arms were in line, and the direct image of the slit fe

* Given by a misprint 1$^{\mu}$·32 in the December number of this Journal.

on the bolometer. The prism was then placed on its table, the automatic minimum deviation apparatus connected, and the prism set to minimum deviation by a sodium flame held in front of the slit. The deviation of the ray falling upon the bolometer was then given directly by the circle reading to 10″.

The bolometer used was 2^{mm} wide, and consequently subtended an angle of about 20′ in the spectrum. After adjusting the prism, the slit was opened to the same width. A secondary object of the experiment was the determination of the transmission of rock-salt in different parts of the spectrum, and for this purpose a plate of polished rock-salt, whose thickness was $9{\cdot}1^{mm}$, was interposed at the slit, after each deflection obtained in the ordinary manner, the plate being allowed to remain in each case till the bolometer had registered the heat due to radiations from the salt itself, when the screen was withdrawn and the radiations from the Leslie cube allowed to pass through it.

The results are given below in the form of a table.

Deviation.	Deflection.	Deflection with rock-salt plate interposed.	Transmission of plate.
40° 30′	12		
40 00	72		
39 30	214		
39 00	364		
38 30	420	360	·857
38 00	365		
37 30	269	251	·933
37 00	196		
36 30	137	122	·891
36 00	96		
35 30	62	63	1·02
35 00	48		
34 30	29	27	·931
34 00	26·5		
33 30	18	14	·778
33 00	10.5		

The "transmission" of the plate of rock-salt (here uncorrected for heat lost by reflection at the anterior surface) has been shown by subsequent experiments to very slightly diminish for extreme infra-red heat rays in the Leslie cube spectrum; but to remain so nearly constant through the range of these experiments, as to show that the present approximate values need no correction on this account. More exact ones will be given in a subsequent memoir.

The following series was then taken for fixing more accurately the position of the maximum:

Deviation.	Deflection.
39° 00′	375
38 50	406
38 40	430
38 30	428
38 20	414
38 10	401
38 00	371

From curves representing these observations, it was co cluded that the maximum was at 38° 35′. It will be show further on, how an attempt may be made to estimate the wav lengths in these regions.

Measurements were also made with surfaces of copper heat to much higher temperatures, and with the cube at differe lower temperatures, for the purpose of determining wheth the position of the maximum of the energy curve varies wi the temperature, and if so, to determine if possible the relatio Experiments of this kind have been made by Mr. W. V Jacques,* who found that "the distribution of heat in t spectrum of a solid or liquid source of radiation is nearly ind pendent of the temperature of the source." It was evide from the care with which Mr. Jacques's experiments were co ducted, that the shifting of the maximum must be slight a difficult of quantitative determination, but with the pure spe trum and delicate heat-measuring apparatus at our comman it was thought possible that this might be effected. Accor ingly, measurements similar to those just described were ma with a radiating surface of lamp-blacked copper at the appro mate temperatures of 815° C., 525° C. and 330° C., and wi the Leslie cube at temperatures of 178° C., 100° C., 40° C., a −20° C., the excess over the temperature of the room being the latter cases respectively 185° C., 88° C., 46° C., and −1 C. In the last instance, the cube was colder than the bolo eter strips, and the deflections obtained were negative; thou small, they were distinctly measurable, the greatest being − divisions of the galvanometer scale.† We have in Plate 3 t curves representing the radiation from these sources, in whi the abscissæ are proportional to the indices of refraction in t rock-salt prism, but the ordinates only approximately so to t deflections of the galvanometer due to the heat at the cor sponding points, since we are not here primarily concerned wi the relation of the amounts of heat emitted to the temperatu

* Distribution of heat in the spectra of various sources of radiation, by Willi W. Jacques, Ph.D., Proceedings of the American Academy.

† The position of the maximum in the ice curve is indicated, but the curve it is, on this scale of ordinates, sensibly coincident with the straight line. (S Plate 1.)

of the sources of emission, but chiefly with the secondary effect of the progressive movement of the maximum which is clearly shown.

Date of observation.	Approximate temperature of source.	Approximate temperature of excess.	Deviation of maximum ordinate in heat curve.
1885.			
October 7,	815° C.	803° C.	39°·08′
" 3,	525	505	39·03
" 7,	330	318	39·01
" 3,	330	310	39·00
September 26,	300	275	38·42
March 20,	178	185	38·35
August 19,	179	152	38·35
March 20,	119	126	38·25
October 7,	100	88	38·22
" 3,	99	79	38·27
March 21,	40	46	38·00
" 24,	−02	−18	37·40*

It is to be observed of each of the curves in Plate 3, that though nearly all the *area* is seen, yet that, owing to the extension of the heat curve toward the right, the length shown is limited here by the size of the plate, whereas the extremity measured in each curve (except of course the solar one) does, in fact, correspond to an index of less than 1·45. We give above a table showing the dates of observation, the approximate temperatures of excess and the approximate deviations of the ordinate corresponding to the point of maximum heat in the (rock-salt) prismatic spectrum. We should observe that the higher temperatures are here only determined with an approximation sufficient to make it certain that there is a progression in the direction of the shorter wave-lengths of the position of the maximum heat-ordinate corresponding to the temperature, as the latter rises. These results, both in the table and as represented in the plates, are given as preliminary, not as final, for we hope soon to be able to offer other and more exact ones, deduced from the heat spectra of bodies at all temperatures between that of melting platinum and melting ice. We are entitled, however, even at present, to draw the following conclusions, which are of special interest in connection with the spectra of dark bodies, of which almost nothing has been hitherto known.

(1) The heat represented by the areas of these curves is *almost altogether of a character not observed in that of the sun*, these wave-lengths, in general, not being transmissible by glass, which is comparatively permeable to the lowest solar

* The position of the maximum in this latter case depends upon a single observation of some delicacy and is liable to subsequent correction.

heat waves that penetrate our atmosphere.* To show th more clearly we have drawn the solar spectrum given by tl rock-salt prism in its true position (though not in its tr amount) relatively to that of the heat curves cited. The ma imum of the latter lies in every case, it will be seen, far belc the very lowest part of the solar invisible heat.

(2) In spite of the compression of the infra-red by the pris these heat curves extend almost indefinitely in the direction the smaller indices, so far that we can, in fact, represent only part of this extent in our plate. The measures already cit in case of the curve for the Leslie cube at 178°, for instan show very measurable heat at a deviation of 33°, which cor sponds to an index of refraction of 1·4511, while the small index given in the plate is 1·49.

(3) An increase of temperature increases every ordinate, b not in like proportions, ordinates corresponding to the heat the more refrangible parts always growing more rapidly th those for less refrangible heat.

(4) As a necessary consequence of this, follows the (ind pendently observed) fact of the progressive movement of tl maximum ordinate toward the more refrangible end, as tl temperature rises.

(5) These prismatic curves are not symmetrical, the great portion of the area in every case lying below the maximu *i. e.*, toward the greater wave-length, and the descent bei always most abrupt on the more refrangible side.

As the heat spectra from surfaces at the temperature of bo ing water or melting ice are those to which the chief inter attaches, in connection with the temperature of the soil, and these are not well shown on the same scale of ordinates wi that of the red-hot copper, we give an independent represen tion of these two in Plate 1, but upon the wave-length, not t prismatic scale. Their maxima of heat fall at points in t normal spectrum which (as we explain later) are only appro mately determinate on *this* scale, but which are probably least as low as the points (*f*) corresponding to the boiling wat maximum, and (*g*) corresponding to the position of the ma mum ordinate in the spectrum of ice, at the melting point, lower. No attempt is made in this plate to represent the re tive amounts of heat in the solar and Leslie cube curves, b only their positions on the wave-length scale; and here also will be understood that the latter curves really extend i further to the right than the limits of the plate admit of sho ing them.

* The distinctive character of those radiations is also well shown by the f we have found that a thick film of lampblack, which is nearly as impervious the dark solar heat as to light, transmits more than 50 per cent of the rays question.

These observations, then, show a real though slight progression of the point of maximum heat toward the shorter wave-lengths as the temperature rises. The position of the maximum ordinate of the lower curves is of course more difficult to determine, on account of their flatness.

The whole heat spectrum from most of these sources, it is interesting to note, passes through the prism at angles which the theories of our text books have heretofore pronounced impossible. The existence of these radiations, and the relative amounts of heat for each deviation, is certain, for these deviations are determined by the spectro-bolometer, in most cases with a probable error of less than a minute of arc; but when we pass to the next stage of our work, the determination of the corresponding wave-lengths, we cannot speak with such confidence. We have calculated the wave-lengths for some of the observations by means of Wüllner's new formula,*

$$n^2-1=-P\lambda^2+Q\frac{\lambda^4}{\lambda^2-\lambda^2_m}$$

where P, Q and λ_m are constants, depending upon the nature of the refracting substance, to be determined by observation.

This formula Wüllner founds on Helmholtz's theory, but he has tested it by our own observations with the glass prism. We have found the calculated values to agree with similar ones obtained directly from the curve representing the relation bebetween n and λ for rock-salt, which is shown in Plate 4, by measurements on points whose wave-lengths were known from our prior observations up to about 23,000 of Ångström's scale. Beyond this point we have continued the curve both by computation and by graphical extrapolation. We do not disguise from ourselves the danger of all extrapolations, although ours rest, it will be seen, on a wholly different basis from the ones depending on formulæ derived from the visible spectrum alone, since our curve has been already followed by direct observations until it is almost coincident with a straight line. Up to this point then (within the limits of error already elsewhere given) there is no doubt, and unless there is some utter change in the character of the curve, such as we have no reason to anticipate, a tangent from the last part will not differ very greatly from the immediate course of the curve itself, and will at any rate meet the axis of abscissæ sooner than the curve can. If we assume then the prolongation of the curve to agree with this tangent, we evidently assume a minimum value for all the wave-lengths measured by it, and that is what we have done.

We are not prepared yet to speak of these wave-length values as exactly determinate, and they are here given as first

* Wiedemann's Annalen, Band 33, p. 307.

approximations. They are indeed sufficiently startling, t make us inclined to proceed with caution; but, speaking wit the reserves indicated by the conditions referred to, I may sa that we have every reason to believe that the minimum wav length assignable to the minimum ordinate of the heat curve, i the spectrum of a source whose temperature varies from 100° · 0° Centigrade, is a little less than 5μ and a little over 6μ and th these may be indefinitely greater. This refers, it will be remarke only to the position of the maximum ordinate, while the extren portions of the curve measured on (corresponding to an index 1·45) have probably at least three times this wave-length. I sh be better understood, perhaps, if I say that some of the heat rac ated by the soil has probably a wave-length of *over* 150,000 Ångström's scale, or about twenty times the wave-length of tl lowest visible line in the solar spectrum, as known to Frau hofer.

These investigations are still going forward, and I hope soc to give more exact values. But I have presented the prese ones, though imperfect, because they give us at least son knowledge of a region of which we are at present quite ignc ant, and because they are thus I think of some interest both the physicist and to the astronomer. To the physicist, as sho ing that the wave-lengths which Newton measured to the $\frac{1}{40,0}$ of an inch are so far from being the limits of nature's scale, tl the existence of measurable wave-lengths of something grea than $\frac{1}{1,000}$ of an inch is rendered at least highly probable. T the astronomer, because we find that *the heat radiated from soil is of an almost totally different quality from that which received from the sun*, so that the important processes by whi the high surface temperature of the planet are maintained, c now be investigated with, we may hope, fruitful results in co nection with the researches here described.

I should not close this preliminary account without stati that I have in these observations been throughout and at eve stage, indebted to Messrs. F. W. Very and J. E. Keeler of t Observatory, for a collaboration without which it could have appeared in its present form.

ART. II.—*Botanical Necrology of* 1885; by ASA GRAY.

CHARLES WRIGHT died on the 11th of August, at Weth field, Conn., at the home where he was born on the 29tl October, 1811, and where the early as well as the later ye of his life were passed. He received his education in grammar school of his native village and at Yale Coll

which he entered in 1831, graduating in 1835. His fondness for botany was developed while he was in college, although, so far as we can learn, he had no teacher. The opportunity of gratifying this predilection in an inviting region may have determined his acceptance, almost immediately after graduation, of an offer to teach in a private family at Natchez, Mississippi. Within a year pecuniary reverses of his employer terminated this engagement. At this time there was a flow of immigration into Texas, then an independent republic; and Mr. Wright, joining in it, in the spring of 1837, made his way from the Mississippi to the Sabine, and over the border, chiefly on foot, botanizing as he went. Making his headquarters for two or three years at a place then called Zarvala, on the Neches, he occupied himself with land-surveying, explored the surrounding country, "learned to dress deer-skins after the manner of the Indians, and to make moccasins and leggins," "became a pretty fair deer-hunter," and inured himself to the various hardships of a frontier life at that period. When the business of surveying fell off he took again to teaching; and, in the year 1844, he opened a botanical correspondence with the present writer, sending an interesting collection of the plants of Eastern Texas to Cambridge. In 1845 he went to Rutersville in Fayette County, and for a year or two he was a teacher in a so-called college at that place, or in private families there and at Austin, devoting all his leisure to his favorite avocation. In the summer of 1847–8 he had an opportunity of carrying his botanical explorations farther south and west. His friend Dr. Veitch, whom he had known in Eastern Texas, raised a company of volunteers for the Mexican war, then going on (Texas having been annexed to the United States), and gave Mr. Wright a position with moderate pay and light duties. This took him to Eagle Pass on the Mexican frontier, where he botanized on both sides of the river. He returned to the north in the autumn of that year, with his botanical collections, and passed the ensuing winter in Connecticut and at Cambridge.

In the spring of 1849, Mr. Wright returned to Texas, and, at the beginning of the summer, with some difficulty obtained leave to accompany the small body of U. S. troops which was sent across the unexplored country from San Antonio to El Paso on the Rio Grande. Notwithstanding some commendatory letters from Washington, no other assistance was afforded than the conveyance of his trunk and collecting paper. He made the whole journey on foot, boarded with one of the messes of the transportation train, and endured many privations and hardships. The return to the seaboard, in autumn, was by a rather more northerly route and under somewhat less

untoward conditions. The interesting collection thus made first opened to our knowledge the botany of the western part of Texas. It was published, as to the Polypetalæ and Compositæ, in the third volume of the Smithsonian Contributions to Knowledge, as *Plantæ Wrightianæ*, part 1, in 1852.

A year and more was then passed in the central portion of Texas, awaiting the opportunity for other distant explorations, supporting himself in part by teaching a small school. At length, in the spring of 1851, he joined the party under Col. Graham, one of the commissioners for surveying and determining the United States and Mexican boundary from the Rio Grande to the Pacific, accepting a position partly as botanist, partly as one of the surveyors, which assured a comfortable maintenance and the wished-for opportunity for botanical exploration in an untouched field. Attached only to Col. Graham's party, he returned with him without reaching farther westward than about the middle of what is now the territory of Arizona, and in the summer of 1852 he returned with his extensive collections to San Antonio, and thence to Saint Louis, to deliver his Cactaceæ to Dr. Engelmann, and with the remainder to Cambridge. These collections were the basis of the second part of *Plantæ Wrightianæ*, published in 1853, and, in connection with those of Dr. Parry, Professor Thurber and Dr. J. M. Bigelow, etc., of the *Botany of the Mexican Boundary Survey*, published in 1859. As Mr. Wright collected more largely than his associate botanists, and divided his collections into sets, his specimens are incorporated into a considerable number of herbaria, at home and abroad, and are the types of many new species and genera. No name is more largely commemorated in the botany of Texas, New Mexico, and Arizona than that of Charles Wright. It is an Acanthaceous genus of this district, of his own discovery, that bears the name of *Carlowrightia*. Surely no botanist ever better earned such scientific remembrance by entire devotion, acute observation, severe exertion, and perseverance under hardship and privation.

Mr. Wright's next expedition was made under more pleasant conditions. It was a long one, around the world, as botanist to the North Pacific Exploring Expedition, fitted out under Captain Ringgold, who was during the cruise succeeded by Commander John Rodgers. After passing the winter of 1852–3 at his home in Connecticut and at Cambridge, he joined this expedition in the spring, and sailed in the U. S. Ship Vincennes from Norfolk, Virginia, on the 11th of June. The collections made when touching at Madeira and Cape Verde were of course unimportant; but at Simon's Bay, just round the Cape of Good Hope, a stay of six weeks resulted in a very considerable collection of about 800 species, within a small

area, the Cape being wonderfully crowded with kinds of plants. The voyage was thence to Sydney and through the Coral Sea to Hongkong, which was reached about the middle of March, 1854. The collection of over 500 species of phænogamous plants which was made during that spring and summer, upon this little island, and supplemented in the spring of 1855, was in part the basis of Bentham's *Flora Honkongensis*. In the autumn of 1854, interesting collections were made on the Bonin and Loo Choo Islands, and later upon the islands between the latter and Japan. Still more extensive and important were the botanical collections made in Japan, especially those of the northern island, although the stay was brief. Also those made in Bering Straits, mainly on Kiene or Arakamtchetchene Island, on the verge of the polar sea, where the scientific members of the expedition passed the month of August and a part of September, 1855. Reaching San Francisco in October, the season being unpropitious for botany, Mr. Wright was detached from the expedition, and came home by way of San Juan del Sur and Nicaragua, botanizing for a few weeks upon an island in the Lake, and thence by way of Greytown to New York.

In the following autumn (of 1856) Mr. Wright began his prolific exploration of the botany of Cuba. Landing at Santiago de Cuba, on the south-eastern part of the island, he passed the winter of 1856–7 and the greater part of the ensuing summer in that nearly virgin district, most hospitably entertained by his countryman Mr. George Bradford, and among the caffetals of the mountains by M. Lescaille, returning home with his rich collections early in the autumn. A year later he revisited Cuba, was again received by his devoted friends, extended his botanical explorations to the northern coast, and also farther westward, exchanging the dense virgin forest for open pine woods, like those of the Atlantic Southern States, stopping at various *hatos* or cattle-farms on his route, but reaching better accommodations at Bayamo, when his kind host, Dr. Don Manuel Yero, assisted him in making some profitable mountain excursions. In the winter and spring of 1861 he was again domiciled with the Lescailles at Monte Verde and at the other coffee-plantations of this kind family; and from thence he was able to extend his herborizations to the eastern coast from Baraçoa to Cape Maysi. The next winter he made his way westward to near the center of the island, making headquarters at the sugar plantation of the hospitable Don Simon de Cardenas, thence visiting the *Cienaga de Zapata*, a great marshy tract toward the south coast. In early summer he transferred his indefatigable operations to the *Vuelt-abajo*, as it is called, or that part of Cuba westward of Habana, making his home at Balestena, a cattle-farm at the southern base of the

mountains opposite Bahia Honda, where he was long most hospitably entertained by Don Jose Blain and Don F. A. Sauvalle. From thence he pushed his explorations nearly to the southwestern extremity of the island at Cape San Antonio. In the summer of 1864 he came home with his large collections, remaining there and at Cambridge for about a year.

In the autumn of 1865, he went again and for the last time to Cuba, again traversed the *Vuelt-abajo* in various directions, proceeded by steamer to Trinidad and botanised in the mountains behind that town, thence by way of Santiago he revisited the scenes of his earlier explorations and the surviving friends who had efficiently promoted them. The oldest and best of them, the elder Lescaille, was now dead. In the month of July, 1867, our persevering explorer came home.

Mr. Wright's Cuban botanical collections, from time to time distributed into sets, with numbers, were acquired by several of the principal herbaria,—the fullest sets of the Phænogamous and vascular Cryptogamous plants, by the herbarium of Cambridge and by the late Professor Grisebach of Göttingen. Professor Grisebach was in these years engaged with his Flora of the British West Indies; so that he gladly undertook the determination of the plants of Cuba. They were accordingly mainly published in Grisebach's two papers, *Plantæ Wrightianæ e Cuba Orientali*, in the Memoirs of the American Academy of Arts and Sciences, 1860 and 1862, and in his *Catalogus Plantarum Cubensium exhibens collectionem Wrightianam aliasque minores ex Insula Cuba missas*, an 8vo. volume, published at Leipsic in 1866. The latter work enumerates the Ferns and their allies: but those for the earlier part were published in 1860 by Professor Eaton, in his *Filices Wrightianæ et Fendlerianæ*, a paper in the eighth volume of the Memoirs of the American Academy. The later collections are incompletely published in the *Flora Cubana*, a volume issued by F. A. Sauvalle at Habana, in 1873 and later,—a revision of Grisebach's Catalogue (without the references, but with Spanish vernacular names attached) which was made by Mr. Wright, who added descriptions of a good many new species. The only other direct publication by Mr. Wright is his *Notes on Jussiæa*, in the tenth volume of the Linnæan Society's Journal. As to the lower Cryptogams, Mr. Wright's very rich collections were distributed in sets and published by specialists; the *Fungi* by Berkeley and the late Dr. Curtis; the *Musci*, by the late Mr. Sullivant, the *Lichenes*, by Professor Tuckerman in large part, and certain tribes quite recently by Müller of Geneva. So Mr. Wright's name is deeply impressed upon the botany of the Queen of the Antilles.

There was a prospect that he might do some good work for the botany of San Domingo. For in 1871, a Government ves-

sel was sent to make some exploration of that Island, and Mr. Wright went with it. It was in winter, the dry season, and the excursion across the country was hurried and unsatisfactory; so the small collection made in this, his last distant botanizing, was not of much account.

Mr. Wright's botanizing days were now essentially over. He made, indeed, a visit to the upper part of Georgia in the spring of 1875. But this was mainly for recuperation from the effects of a transient illness, and for seeing again a relative and companion of his youth from whom he had long been separated. A large part of several years was passed at Cambridge, taking a part of the work of the Gray Herbarium; and one winter was passed at the Bussey Institution, in aiding his associate of the South Pacific cruise, Professor Storer. Of late there fell to him the principal charge of the family at Wethersfield, consisting of a brother who had become an invalid, and of two sisters in feeble health, all unmarried and ageing serenely together. By degrees his own strength was sapped by some organic disease of the heart, which had given him serious warning; and on the eleventh of August he suddenly succumbed, while making his usual round at evening to look after the domestic animals of the homestead. Not returning when expected, he was sought for; the body was found as if in quiet repose, but the spirit had departed.

Mr. Wright was in person of low stature and well-knit frame, hardy rather than strong, scrupulously temperate, a man of simple ways, always modest and unpretending, but direct and downright in expression, most amiable, trusty, and religious. He accomplished a great amount of useful and excellent work for botany in the pure and simple love of it; and his memory is held in honorable and grateful remembrance by his surviving associates.

George W. Clinton died, at Albany, on the 7th of September last, in the 78th year of his age. He was the son of DeWitt Clinton, one of the most distinguished governors, and the grand-nephew of George Clinton, the first governor of the State of New York. He was born on the 13th of April, 1807, whether in the city of New York or in the home on Long Island is uncertain; he became a student in Albany Academy in the year 1816, when his father entered upon his first tenure of office as governor, entered Hamilton College in 1821, was graduated in 1825, was led by his early scientific tastes to the study of medicine, which he pursued for a year or two. At least he attended two courses of lectures at the then flourishing country medical school at Fairfield, N. Y. There his acquaintance with Professor James Hadley further developed his

fondness for chemistry and botany, as it did that of the writer of this notice a few years afterward. He also came under the instruction or companionship of Dr. Lewis C. Beck, a younger brother of his medical preceptor Dr. T. Romeyn Beck, attended a course of private lectures on Botany given by Dr. Wm. Tully, entered into correspondence with Rafinesque, Torrey, etc., and so bid fair to give himself to scientific studies, as we may suppose with the approval of his father, who, it is well known, had a decided scientific bent. But Governor Clinton's death in February, 1828, wrought a change in his prospects and in the course of his life. Acting upon the advice of his father's friend, Ambrose Spencer, the distinguished Chief Justice of the State, he took up the study of law, attended the law lectures of Judge Gould at Litchfield, Connecticut, and continued his studies at Canandaigua, N. Y., in the office of John C. Spencer, whose daughter he married. Admitted to the bar in 1831, he established himself at Buffalo in 1836, and practiced his profession most acceptably at the bar until the year 1854, when he became judge of the Superior Court of that city. This honorable position he continued to hold with entire approbation until January, 1878, when he retired under the provision of the constitution upon attaining the age of 70 years. Then he resumed the practice of the law for two or three years; but at length he took up his residence in Albany, partly for the more convenient rendering of his service as a Regent of the University of the State, and its Vice Chancellor, but mainly for investigating and editing the papers and writings of his great uncle George Clinton. On the afternoon of the 7th of September he took an accustomed walk in the Rural Cemetery of Albany, and there he died, probably quite instantaneously; for when his body was found two or three hours later, some unwithered sprays of White Melilot, which he had gathered, were still clasped in his hand.

Judge Clinton's professional life need not here be considered. I did not know him, but knew of him, as a botanist in his younger days. About the year 1860, after buying a botanical book for his daughter, the turning over its pages revived an almost forgotten delight; and when his attention was again given to the flowers he had long neglected, we soon came into correspondence. "I might have become a respectable naturalist," he writes, "but was torn from it in my youth. . . . To become a botanist is now hopeless; I am, and must remain, a mere collector. But then I collect for my friends and for the Buffalo Society of the Natural Sciences. If I can please my friends and help the Society, it pleases me. I want it to succeed. Money I cannot give it, and I give it all I can, the benefit of my example and pleasant labors." An instructive and

asant, and on his part a sprightly correspondence it has been; d most ardent and successful were his efforts in the development of the Society of Natural Sciences over which he preied, and especially of its herbarium which he founded. In the ring of 1864 he wrote: "To-morrow I believe I shall be able mail you my Preliminary List of the Plants of Buffalo. nd I demand that, immediately upon its reception, you write e, saying 'pretty well for you.' I do feel gratified that I have last made the mitiest mite of a contribution to science. I ow how extremely minute it is. I would not be so exactg but for the fact that my letter-book is just full, and I want commence a new one with a letter from you, I mean with a te from you: a letter is too ambitious."

As this modest Preliminary List exemplifies the beginning, the full and critically prepared Catalogue of the Native and aturalized Plants of the City of Buffalo and its Vicinity (pp. 5), published in 1882–3, marks the conclusion and shows the uits of Judge Clinton's work upon the flora of the district ound Buffalo. This Catalogue was, indeed, prepared and iblished by his near friend and associate, Mr. Day, with a oroughness and judgment which have been much commended. But the collection and elaboration of the materials, e critical determination of the species, and the preparation of e "Clinton Herbarium," as it is now appropriately called, were sentially his own work in the *horæ subsecivæ* of a busy prossional life. If during middle life, and while making his ay in his chosen vocation he abandoned his early scientific vocation, he took it up again when he had achieved a position hich allowed some well-earned leisure, and he pursued it with n added zeal and energy and acumen, which should give his ame a place among the botanical worthies,—to be remembered fter those who knew and appreciated and loved him have assed away. A little Scirpus specifically bears his name, ut I never see the modest liliaceous plant of our northern oods, called *Clintonia* in honor of the father, without associting it with the son.

Judge Clinton's contributions to the literature of the legal rofession consisted mainly of his Digest of the Decisions of he Law and Equity Courts of the State of New York, in three tout volumes. But he was a not unfrequent and a fascinating riter in the newspapers of the city, an occasional lecturer pon historical as well as scientific topics, and an organer or promoter of every good civic work. He was a peron of marked and distinct individuality. It has been said of m that "he was not like anybody else, did not look like anydy else, and did not talk like anybody else." But his ways d his conversation were peculiarly winning and delightful.

Of a rather large family of children, four survive, two of them sons, and a goodly number of grandchildren.

EDMOND BOISSIER died on the 25th of September, at his country residence in Canton Vaud, Switzerland, at the age of seventy-five years and three months. Having known him personally almost from the beginning of his botanical career, which has been so honorable and distinguished, it is a melancholy satisfaction, as well as duty, to pay this passing tribute to his memory.

Boissier came from one of those worthy families which were lost to France and gained to Geneva by the revocation of the Edict of Nantes,—a family that has proved its talents and high character in more than one of its members. Madame the Countess de Gasparin is a sister, next to him in age, and the two had their education very much in common. He was born at Geneva, May 25, 1810, brought up and educated there, except that the summers were passed at his father's place at Valeyres which he in time inherited, and where his life was closed. From his youth he was fond of natural history and of travel. It was not in his disposition, nor of the Genevese spirit of that day, to lead an aimless life; so, when he came to choose what may be called his profession, it was natural that, at Geneva, in the days of the elder De Candolle, he took to botany. He showed his great good sense by his early judicious choice of a field and by his unbroken devotion to it. To the Mediterranean region, to Southern Spain, and the Orient most of his work relates. After a year or two of careful preparation he went to Spain, in 1837, explored especially Granada and the eastern Pyrenees, and between 1839 and 1845 brought out his *Voyage Botanique dans le midi de l'Espagne*, in two large quarto volumes, the first of narrative and plates, 180 in number, the second of descriptive matter relating to the Granadan flora. Among the species he brought to light was the *Abies Pinsapo*, the beautiful fir-tree now so well known in cultivation. His narrative, besides its botanical interest, is charming reading.

In 1842, after his marriage to his cousin, of the de la Rive family, he traveled with his wife in Greece, Anatolia, Syria, and Egypt. It was to his dear companion that he dedicated two of their joint discoveries, *Omphalodes Luciliæ* and *Chionodoxa Luciliæ*. In 1849 he experienced the great sorrow of his life in her death from typhoid fever, during a second journey in the south of Spain. Between 1842 and 1854 he published the first series of his *Diagnoses Plantarum Orientalium Novarum*, filling two volumes, and in 1855 the second series of almost equal extent; in 1848 he completed his monograph of the *Plumbaginaceæ;* in 1862 he promptly finished his conscientious elaboration of the great genus *Euphorbia* for DeCan

dolle's Prodromus, and in 1866 brought out the *Icones Euphorbiarum*, of 120 folio plates from outline drawings by Heyland. In 1861 he made a trip to Norway with his associate, Reuter. Not to mention other journeys, he was again in Spain and adjacent countries in 1877, and lastly, in 1881, his eighth visit,—then in wretched health. Passing by scattered papers of his, we come to his great work, the *Flora Orientalis*, in five octavo volumes. It comprehends Greece and Turkey up to Dalmatia and the Balkans; the Crimea; Egypt up to the first cataracts; Northern Arabia down to the tropical line; Asia Minor, Armenia, Syria, and Mesopotamia; Turkestan up to 45° of latitude; Persia, Afghanistan, and Beloochistan—that is, up to the borders of India. The first volume was published in 1867; the fifth, in 1884, brings the work down to its conclusion with the Pteridophytes; and the manuscript for a supplementary volume, for recent discoveries and some re-elaboration, was about half finished when he laid down his pen under an attack seemingly no worse than the many he had recovered from, but which now terminated his earthly life.

It was a noble life, shadowed by an early bereavement, and in later years worn by painful disease,—the manly life of one who lived simply and wrought industriously where many others with his independent fortune would have lived idly and luxuriously; and he was no less a loyal and public-spirited citizen. Upon an occasion when, long ago, we met him at Geneva, he had no time for botanical parlance, for he was doing duty in the ranks of the federal army. Later, at a time of commotion at Geneva, he helped to quell a revolutionary riot, and received a painful bayonet wound in the service. True to his ancestry, he was a devoted Protestant Christian, a trusted member of the synod of the Free Church in Canton Vaud, where he lived when not in winter residence at Geneva, and where his assiduous attentions to the poor and the sick will be remembered. He was a man of fine presence, and till past middle life of much bodily vigor. As a botanist he gave himself to systematic work only, for which he had a fine tact, and, like the school in which he was bred, perhaps a faculty for excessive discrimination. No man living knew the Europeo-Caucasian plants so well, or could describe them better; and his herbarium must be, with possibly one rival, the most extensive and valuable private collection in Europe. He loved living flowers as well, and rejoiced in his choice conservatory collections at Rivage, on the shores of the Leman, and in his well-stocked rock-works of alpine plants which adorn his grounds at Valeyres.

A charming biographical notice by one who knew him well through his whole life, M. de Candolle, is contained in the Archives des Sciences of the Bibliothéque Universelle de Génévе for October last.

JOHANNES AUGUST CHRISTIAN ROEPER died on the 17th of March, 1884, at the age of eighty-four. He had been for some time the oldest botanist we know of, at least the oldest botanical author; for his first work, a monograph of the German species of *Euphorbia*, was published in 1824. He was director of the Botanic Garden at Basle in 1828, when he published his classical paper *De Organis Plantarum*, and he may have been so in 1826, when he contributed to Seringe's Melanges Botaniques his paper on the nature of flowers and of inflorescences, which first put the latter upon a scientific basis and essentially established the present nomenclature. He was botanical professor there in 1830, when he published his tract *De Floribus et Affinitatibus Balsaminearum*. In these essays he gave the promise of being one of the foremost morphological botanists of the age. Some time before the year 1840 he was translated to Rostock, where he held the botanical professorship for more than forty years, but without fulfilling the promise of his youth by additional contributions to the science of any considerable importance. There are, however, some articles from him in the Botanische Zeitung, and other German periodicals, the latest in the year 1859. In 1851 he was chosen a Foreign Member of the Linnean Society of London. We find no record of the place or time of his nativity, but we infer from a statement in the preface of his work on Euphorbia, which was published at Gœttingen, that he was German, and not Swiss. He is said to have been most amiable, and of deep religious convictions.

ART. III.—*The Isodynamic Surfaces of the Compound Pendulum*;* by FRANCIS E. NIPHER.

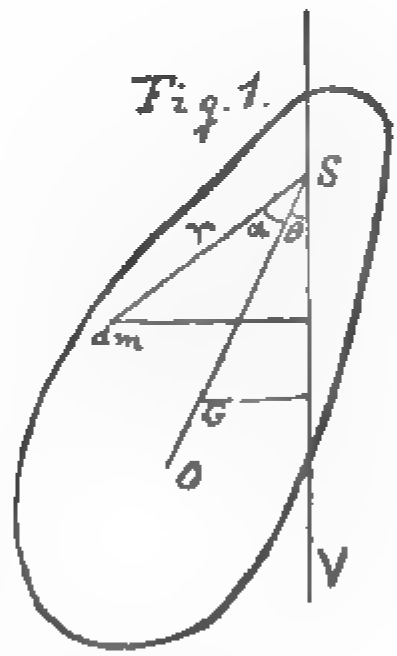
IN discussing the compound pendulum, the statement is sometimes made, that particles near and below the axis of suspension are retarded, and that those near the bottom of the pendulum are accelerated by reason of their connection with the system. The series of particles forming the axis of oscillation are neither accelerated nor retarded.

In a general way, so far as it concerns the time of a complete oscillation, this is all true, but it is not true in any compound pendulum that the particles near the bottom continually exert a retarding effect upon the system. At any given instant, certain particles in the system tend to diminish the actual accelera-

* Read before the St. Louis Academy of Science, Oct. 19th, 1885.

tion, while others tend to increase it. These two tendencies always balance, although the value of each continually varies. These two groups of particles are separated by a surface, each particle of which has no tendency to change the acceleration of the system, at that instant. The axis of oscillation always lies in this surface. On either side of this neutral surface there must be surfaces of equal tendency, those on one side having a plus, and those on the other side a minus sign. It is required to find the loci of these isodynamic surfaces at any given instant. This can be done by means of well known equations for the pendulum, which are first given.

In fig. 1, let O represent the axis of oscillation, G the center of gravity, and S the axis of suspension. Call S G=K; S O=l, and let r be the distance of any element of mass dm from the axis S. Let θ=the angle V S O, and a the angle between the lines l and r, V S being the vertical plane containing the axis S.



The entire mass of the pendulum may be supposed condensed on the vertical plane passing through G, and at right angles to the axes O and S, each element of mass being supposed to be projected along a line parallel to those axes. The pendulum then becomes a thin plate of varying density, lying in the plane of the paper as in fig. 1.

This supposed condensation is really unnecessary in a rigid system, as the center of gravity G, and the element $d\,m$, may lie in different planes, at right angles to the axis S without in any way changing the result.

At any instant the linear acceleration of O is $g \sin \theta$ and its angular acceleration is $\frac{g}{l} \sin \theta$. This is also the angular acceleration of every other particle in the system. The linear acceleration of $d\,m$ is therefore $\frac{r}{l}\, g \sin \theta$. The force required to produce this acceleration on $d\,m$ is

$$F' = dm\, \frac{r}{l}\, g \sin \theta.$$

The moment of this force about S is

$$F'r = dm\, \frac{r^2}{l}\, g \sin \theta \qquad (1)$$

If the element $d\,m$ were disconnected from the system, its

linear acceleration in falling as a simple pendulum would be $g \sin(\theta+\alpha)$ and the moment of the force required to produce this acceleration would be

$$F''r = dm\, rg \sin(\theta+\alpha) \tag{2}$$

Subtracting (1) from (2),

$$r(F''-F') = dm\, g\, r \sin(\theta+\alpha) - dm \frac{r^2}{l} g \sin\theta \tag{3}$$

The factor $F''-F'=d\,F$ is a force which must be impressed upon dm in excess of its tangential weight-component, in order to impart to the element its real acceleration at the given instant. This force may be either positive or negative, the sign depending upon the position of $d\,m$, and the direction of swing. The integral of (3) for the entire system is necessarily zero, or,

$$\int dm\, g\, r \sin(\theta+\alpha) - \frac{g}{l}\sin\theta \int dm\, r^2 = 0. \tag{4}$$

The first term is the moment of the weight of the system, referred to the plane VS. The second integral is the moment of inertia I, referred to the axis S. Hence,

$$MgK \sin\theta - \frac{g}{l}\sin\theta\, I = 0.$$

Where M represents the entire mass of the pendulum. This gives the well known value of l.

$$l = \frac{I}{M \cdot K}$$

The loci of the isodynamic lines in the disc pendulum are determined from (3), which may be put into the following form:

$$\frac{r\,d\,F}{g\,dm} = r\sin(\theta+\alpha) - \frac{r^2}{l}\sin\theta \tag{5}$$

This expression represents the moment of the impressed force $d\,F$ per unit of weight at any point determined by the values r, θ and α. Making this value constant $=a$, it gives the condition for an isodynamic line, which is therefore—

$$a = r\sin(\theta+\alpha) - \frac{r^2}{l}\sin\theta \tag{6}$$

Let S be the origin of a system of rectangular coördinates, x being the horizontal and y the vertical coördinate of dm. Then as $r^2=x^2+y^2$ and $\sin(\theta+\alpha)=\frac{x}{r}$, equation (6) becomes,

$$x^2+y^2 - \frac{l}{\sin\theta}x + \frac{l}{\sin\theta}a = 0. \tag{7}$$

For a fixed value of θ and a varying value of a, this is the equation of a series of concentric circles, the common center being on the horizontal through S at a distance $\pm\frac{1}{2}\frac{l}{\sin\theta}$ from

S. The radius of any circle is

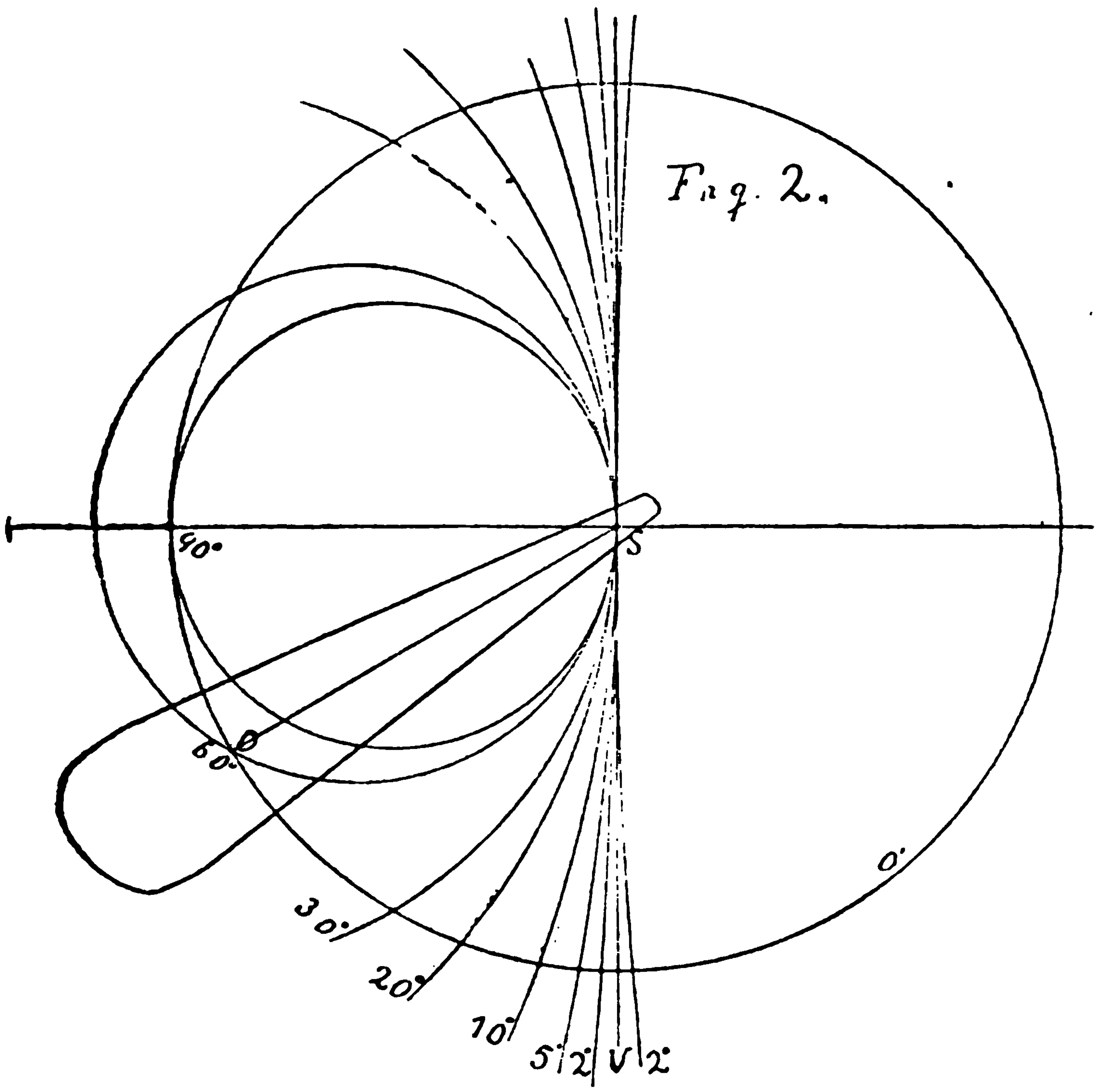
$$R=\sqrt{\frac{l}{\sin\theta}\left(\frac{l}{4\sin\theta}-a\right)} \qquad (8)$$

If $a=o$, we have the condition that the motion of a particle is unaffected by its connection with the system. The radius of of this neutral circle is therefore

$$R'=\tfrac{1}{2}\frac{l}{\sin\theta} \qquad (9)$$

Equation (7) then becomes the equation of a circle containing the two points O and S, and tangent to VS at the point S.

When S O is horizontal, R′ becomes $\frac{1}{2}l$ and when it is vertical $R'=\infty$. The position of the neutral circle for various values of θ is shown in fig. 2. For a pendulum of 39 inches, vibrating 2° on each side of the vertical, the radius of the neutral circle, or the distance of the common center varies between ± 46 feet and ±∞.



Within the pendulum, the circle never departs materially from the tangent SV, particles on the one side tending always

to increase, while those on the other side tend to diminish actual acceleration of the pendulum.

In (8) the condition $a = \frac{l}{4 \sin \alpha}$ or $a = \frac{1}{2}R' = a'$, reduces the dius to zero. This gives the value of a at the center of t concentric circles. If the value of $\frac{l}{\sin \theta}$ as deduced from (9) substituted in (8) it becomes

$$a = \tfrac{1}{2}R' - \frac{1}{2R'} R^2 \qquad (10)$$

This is the equation of a parabola, the position of whc vertex is given by the conditions

$$y = 0$$
$$x = R'$$
$$z = a' = \tfrac{1}{2}R'$$

the distance z being, of course, laid off at right angles to t plane of x, y. Revolving this parabola about its transve axis, which is parallel to the axes O and S, the paraboloid revolution obtained will represent the relation between a a R for every point in the field. The changes which this surfa undergoes during an oscillation of the pendulum, are ve curious and interesting, but it is unnecessary to enlarge up them here, further than to remark that the focus of the par oloid is always in the axis x, and its vertex is always in o of two right lines lying in a horizontal plane and making angle of 30° with the axis x, and intersecting at S.

These considerations are wholly independent of the ma mum amplitude of swing, and also of the geometry of the p dulum, excepting so far as it is involved in the distance l.

The concentric circles which represent the isodynamic lin of the disc pendulum, are of course the right sections of coax cylinders, which represent the isodynamic surfaces of any co pound pendulum.

When $\theta = 0$, these consecutive surfaces become a series vertical and equidistant planes, as is shown by equation (6).

ART. IV.—*The Peridotites of the "Cortlandt Series" on Hudson River near Peekskill, N. Y.;* by GEO. H. WILLIAM

IT is proposed in this paper to give a petrographical desc tion of the most basic members of that interesting group massive rocks which occurs on the southern flank of Archæan Highlands about forty miles north of the city of N York.

The writer is under great obligations to Professor James

Dana of New Haven, who called his attention to these rocks as affording promising material for petrographical study, and kindly volunteered to guide him in an excursion over them in the fall of 1883. A large number of specimens was subsequently collected; but many other pressing duties have since retarded the progress of the work.

This group of rocks, covering an area of not over twenty-five square miles, is composed of many and varied members. It is separated quite sharply from the gneisses, mica-schists and limestones which surround it, showing none of the gradual transitions into these rocks which Hermann Credner, in his description of this district written in 1865,* supposed to exist. Professor Dana, who encountered these rocks in the course of his studies of the limestone belts of Westchester Co., N. Y., designated them as the "Cortlandt Series,"† from their being principally confined to the township of Cortlandt, and published a quite detailed account of their mode of occurrence and macroscopic characters. He at first thought that they might have resulted from the metamorphism of very ancient volcanic ashes stratified by water while the surrounding sediments were being deposited.‡ He has, however, since expressed the opinion, based on several new and excellent exposures, that at least the most basic members of the series are truly exotic, intrusive masses.§

Professor Dana has divided all the massive Cortlandt rocks into five classes according to the nature of their most important non-feldspathic ingredient,‖ viz: (A) Hornblendic (diorite), (B) Hypersthenic (norite), (C) Augitic (diabase and gabbro), (D) Biotitic (diorite) and (E) Chrysolitic (peridotite). This classification may perhaps be advantageously followed, provided it be remembered that no sharp line can be drawn between the different groups; but that, on the contrary, every possible transition from each group into every other occurs. Indeed I know of no other region of massive rocks so well calculated to show the transitions, both sudden and gradual, of one rock-type into another.

The writer now proposes to describe petrographically the different types of the Cortlandt Series in succession, commencing with the most basic; this may be followed by an account of the highly contorted and metamorphosed schists which occur around their edge, while any general conclusions regarding the origin and material of these rocks will be reserved to the last.

Such a study will serve as a contribution to our knowledge

* Zeitschrift der deutschen geologischen Gesellschaft, xvii, 1865, p. 390.
† This Journal, III, xx, p. 194, Sept., 1880.
‡ Ibid., III, xxii, p. 111, Aug., 1881. § Ibid., III, xxviii, p. 384, Nov., 1884.
‖ Ibid., III, xx, p. 196, Sept., 1880.

of the little altered, ancient eruptive rocks of the United States; a knowledge necessary for any intelligent work on the very interesting question regarding the metamorphism of eruptive masses which is now beginning to attract the attention of geologists.

In the present paper only such of the Cortlandt rocks will be described as contain the mineral olivine. These are, for the most part, destitute of any considerable quantity of feldspar and belong therefore to the family of Peridotites; in some cases, however, by an increase in the amount of this constituent, they pass gradually into olivine-norites, olivine-gabbros and olivine-diorites.

Chrysolitic Rocks.

Class I.—*Peridotite* (Rosenbusch.)

This class includes all massive, holocrystalline rocks of a granular structure, which are free from feldspar and contain, as their most characteristic constituent, the mineral olivine. The peridotites have been variously subdivided according to the other minerals which they contain, but for the present purpose it will be necessary to distinguish only two groups, in one of which hornblende, in the other pyroxene, is the most important ingredient. It is not to be understood that the presence of one of these minerals in the least excludes the other; both are always present, but in such varying proportions that it will be advantageous to designate which of the two, in a given case, plays the principal rôle. Both of these groups of peridotite occurring in the Cortlandt Series, are, in some respects, quite different from any which have been heretofore described. They everywhere grade into one another, and into their corresponding feldspathic equivalents.

Of all the rocks occurring in the earth's crust none are so subject to alteration as those composed largely of olivine. Nothing, therefore, can be better calculated to give an idea of the wonderful freshness of all the rocks near Peekskill than the fact that this very mineral is here frequently in an almost unchanged condition. The peridotites weather superficially into a reddish brown soil, but specimens taken from a short distance below the surface show hardly more than the beginning of alteration. The frequent polished and striated rock surfaces met with indicate that the great glacier was probably instrumental in ploughing off and removing the more decomposed material, thus exposing the fresher rock below.*

The distribution of the peridotites within the Cortlandt area is not a very extensive one. They are principally confined to

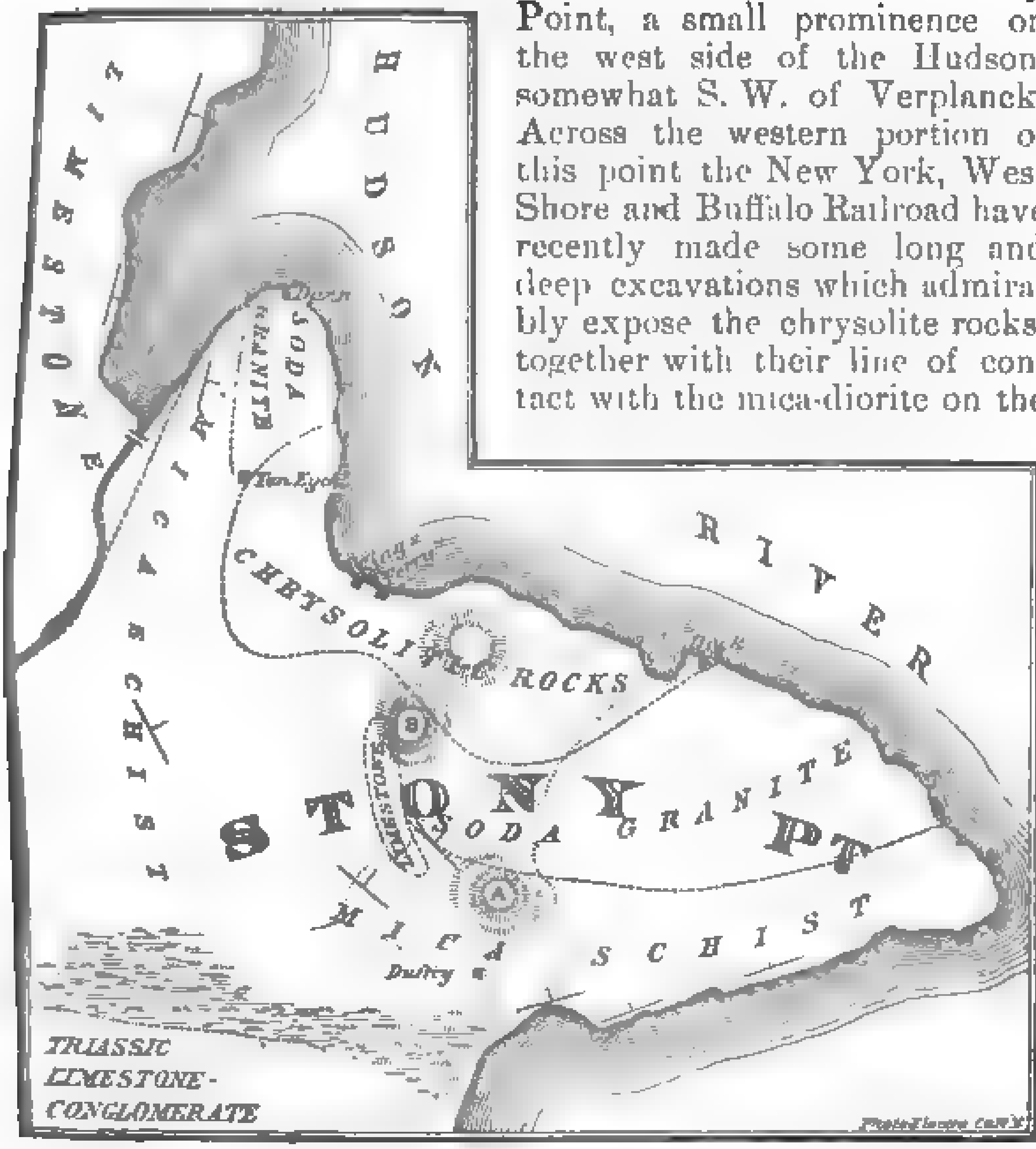
* The freshness of these rocks is doubtless largely due to the relatively small amount of olivine which they contain. This, as will be shown in the sequel, is much less than that usually found in typical peridotites.

the northern half of Stony Point on the west side of the Hudson River, and to the southern portion of Montrose Point on the east side of the river opposite Stony Point. Even here, however, these rocks show a decided tendency to become feldspathic.

1. Hornblende Peridotite.

Hornblende Picrite (Bonney);* *Hudsonite* (Cohen).†

The best locality for specimens of this type of peridotite is at King's Ferry, in the extreme northwest corner of Stony Point, a small prominence on the west side of the Hudson, somewhat S. W. of Verplanck. Across the western portion of this point the New York, West Shore and Buffalo Railroad have recently made some long and deep excavations which admirably expose the chrysolite rocks, together with their line of contact with the mica-diorite on the north and with the mica-schist on the south. The road follows the shore across the northern area of soda-granite (mica-



* Qt. Jour. Geol. Soc., xxxvii, 1881, p. 137. Bonney's name for this group of rocks is not a good one, inasmuch as *picrite*, by the sanction of long usage, indicates an aggregate of olivine and augite. Moreover Bonney considers the compact brown hornblende to have originated from the paramorphism of augite, a supposition which for the brown hornblende of the Cortlandt peridotites at least is wholly untenable.

† This rock resembles very much the well known "Schillerfels," occurring near

diorite), as shown in the accompanying map; and exposes its eastern side in a high wall which is intersected by several fine grained dykes. It continues southward through the chrysolitic area and crosses the point in a deep cutting where the contorted mica-schists, their intersecting dykes and their contact with the peridotite, are all distinctly to be seen. In a small railroad filling near King's Ferry on the north side of Stony Point, large quantities of the peridotite have been thrown out of the adjoining cutting and here many varieties may be collected.

The most remarkable among these varieties is a dark green, at first sight apparently fine-grained rock, which, however, when held in the proper light, exhibits glistening, bronze-colored cleavage surfaces often measuring 3×4 inches. The reflection from these surfaces is, however, not altogether continuous, being interrupted by small rounded grains of a dull green mineral whose nature cannot be determined with the unaided eye but which the microscope shows to be olivine or serpentine.

This is precisely the structure possessed by the "Schillerspath" or "Bastit" of the Harz Mountains, which Professor Aug. Streng described as long ago as 1862.* It does not differ essentially from that of a feldspar crystal in graphic-granite whose cleavage surface is seen in reflected light to be interrupted by particles of uneven quartz. In fact this structure is so common in many massive rocks, especially in the more basic kinds, that I would venture to suggest the use of the term "*poicilitic*" (derived from the Greek ποικίλος, mottled) for it.

Professor Pumpelly has described the same phenomenon in the melaphyres of the Lake Superior region under the name of "*luster-mottlings*,"† a term adopted by Professor Irving for a similar structure which he found developed on a much larger

the village of Schriesheim, a short distance north of Heidelberg in Baden, which has been elaborately described by Prof. E. Cohen (Benecke and Cohen: Geognostische Beschreibung der Umgegend von Heidelberg, 1881, pp. 141–148). This investigator regarded the large bronzy-looking crystals, enclosing smaller grains of the other constituents, as diallage. The same mineral is called "Schillerspath" by Fuchs and Bastite by Groth. Very recently however Cohen has revised his former determination and finds this mineral—as is the case in the Cortlandt rocks—to be hornblende. He therefore proposes to call this type of hornblende-olivine rocks "*Hudsonite*," on account of their extensive development on the Hudson River. (Neues Jahrbuch für Min., etc., 1885, II, p. 242.) This name has already been used by Beck (Mineralogy of New York, 1842) for a variety of diallage occurring near Cornwall, N. Y., so that it would seem to the writer preferable, if a new name is necessary. to adopt the term "*Cortlandtite*" for this class of rocks which play such an important rôle in the "Cortlandt Series."

* He says: "Charakteristish für den Schillerspath ist es, dass er überall von Grundmasse durchsetzt wird, so dass sein deutlichster Blätter-Durchgang mit dunkeln, matten Fleckchen gesprenkelt ist." (Neues Jahrbuch für Min., Geo. und Pal., 1862, p. 533).

† Metasomatic development of the copper-bearing rocks of Lake Superior. Proc. Amer. Acad., vol. xiii, p. 260, 1878.

coarse grained olivine-gabbros of the same district.* I. E. Wadsworth in a recent description of the from Presque Isle, Michigan, alludes to the same and suggests that the reflecting mineral plays the ı the peridotite that the iron does in the pallasites.† .ses heretofore described, the reflecting, bronzy min- s to have been some variety of pyroxene—either llage or enstatite; in the peridotite from King's ·ever, the glistening surfaces, as the microscope those of a brown hornblende.‡ The individuals of l are very large, being often four inches in diameter; hstanding that they are so abundant as to be every· ntact with each other, so full are they of inclusions ;r constituents that they do not together make up the entire mass of the rock. (No. 90.)§

variety of this rock from the same locality, in which ıg surfaces of hornblende are considerably smaller, sher than the one just described. (No. 95.)

scopical examination of these rocks is able to dis· ldition to the ingredients already mentioned, only rticles of magnetic pyrites (pyrrhotite) and glisten· f a light green mica; a microscopical study of them, ;veals much that is interesting.

nblende is undoubtedly the most important and ic constituent of this group of olivine rocks, for it nineral that their peculiar habit is almost wholly it is really hornblende which is present and not, as ıpposed by analogy with similar occurrences, some pyroxene, is proven by the cleavage angle. Several nts on a large Fuess reflection·goniometer gave ing between 124° 15′ and 124° 50′ (calculated angle ıe prism (∞ P) faces for hornblende, 124° 30′).

:amined under the microscope by transmitted light ıl appears of a rich brown color, belonging to the

:r bearing Rocks of Lake Superior. Monographs of the U. S. Geol. 1883, p. 42.

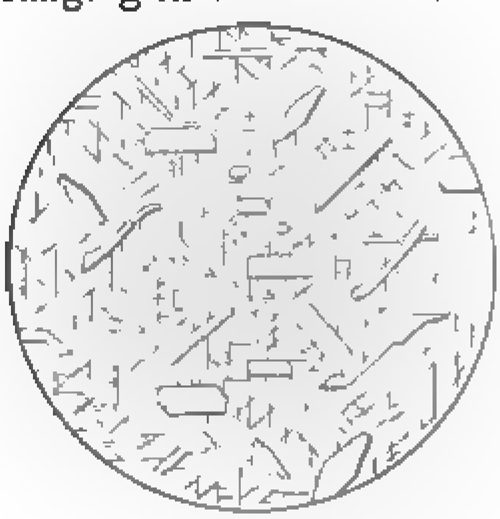
ıl Studies. Part I. Mem. Mus. Comp. Zool. of Harvard College, 1884.

Bonney has recently described a peridotite from Swift's Creek, Australia, which very strongly resembles both the Schriesheim and nt rock. The large cleavage surfaces with an interrupted luster nined to be those of hornblende. This mineral had a green color eak pleochroism. It is considered by the author to be possibly of ;in having been produced by the paramorphism of the pyroxene. ;ical Magazine, vol. vi, p. 54, July, 1884.)

›ers given in connection with the different specimens are those of of Cortlandt rocks belonging to the Johns Hopkins University. In s attached to a number, W. indicates that the specimen or section in ıgs to the writer's private collection, while D. refers to sections :essor James D. Dana, for whose kindness in this respect the writer ; his deep obligation.

variety known as basaltic hornblende. The difference in absorption between the ray vibrating parallel to the axis of greatest elasticity, $\mathfrak{a}$, and either of the others is very marked; but between the rays vibrating parallel to $\mathfrak{c}$ and $\mathfrak{b}$ a difference is hardly observable.* The color of the $\mathfrak{c}$ ray is a dark chestnut; that of the $\mathfrak{b}$ ray the slightest tinge lighter, while $\mathfrak{a}$ is a light yellow. The absorption may be expressed by the formula $\mathfrak{c}=\mathfrak{b} > \mathfrak{a}$.† In sections therefore which lie in the zone $\infty P \grave{\infty} : 0P$ a very strong change of color is observed when the stage is revolved over the polarizer. On the other hand sections nearly parallel to $\infty P \overline{\infty}$ or ∞P remain dark brown by a complete revolution. This accounts for the fact that apparently non-pleochroic hornblende often occurs in the same section with such as is strongly pleochroic. The difference depends only upon the direction in which the mineral is cut. The extinction angle in a section cut parallel to the clinopinacoid, measured against the cleavage lines (vertical axis), gave values varying between 9° and 10°.

The inclusions in this hornblende are both numerous and characteristic. The most common are opaque black needles, ranging in size from the finest dust to about ·03 mm. in length.



The majority of these are arranged either parallel to the vertical axis or else so as to make an angle of about 45° with this. Others appear quite irregular in their position. More rarely small transparent crystals, the largest of which are ·05 mm. long and ·02 mm. broad, occur with the opaque needles. The nature of these could not be determined. They seemed, however, to possess a sharp crystal form, a high index of refraction and a parallel extinction. These are most frequently arranged with their longest axes inclined approximately 45° to the c. axis of the hornblende, or perpendicular to it. Still more rarely than these transparent crystals, the hornblende contains inclusions of thin brown plates similar to those which are so characteristic of hypersthene. All of these interpositions, of which the opaque black needles as a rule occur alone, show a tendency to concentration toward the center of the hornblende, leaving a border near the edge comparatively free from foreign substances.

*In the mineral hornblende. $\mathfrak{b}$ (axis of middle elasticity) coincides with the crystallographic axis $\breve{b}$ (orthodiagonal); $\mathfrak{c}$ (axis of least elasticity) agrees nearly with $\acute{c}$ (vertical axis), while $\mathfrak{a}$ (axis of greatest elasticity and principal bisectrix) is situated in the plane of symmetry at right angles to $\mathfrak{c}$.

† Vid F. Becke, Tschermak's Min. und Petrog. Mitth., 1882, p. 235.

often however they form irregular patches scattered like little clouds over the brown background.*

The hornblende itself never shows any trace of crystalline form. It fills the irregular spaces between the other constituents, a single individual often covering a space some inches square. From its relations to the other minerals in the rock it is evident that it was the last to solidify, while the great size of the crystals would seem to indicate that the process of their formation went on very slowly. If, as seems probable, the portion of this rock now exposed cooled at a very considerable depth below the surface, the minerals like olivine, hypersthene and augite, which are commonly formed at comparatively high temperatures, might have separated out of the magma, leaving the remaining portion, which must have had almost exactly the composition of the brown hornblende, in a more or less pasty condition until the succession of a lower temperature, more in accordance with the amphibole than with the pyroxene arrangements of the molecules, finally allowed it to solidify in its present form. The well-known fact that the same molecule may crystallize at high temperatures as augite and at lower ones as hornblende, renders this a possible explanation of the curious structure of this rock. It is equally applicable to such as contain no hornblende where bastite or diallage present the same appearance. Here also it is the youngest mineral (i. e. the one formed at the lowest temperature) which encloses the others. In this case, however, complete solidification of the rock may have taken place before the temperature was sufficiently lowered to make hornblende a more stable form than pyroxene.

The hornblende seems particularly subject to alteration, which is often far advanced before the olivine or the pyroxene are materially affected. The first change which the hornblende undergoes is a bleaching, accompanying which is the almost

* The inclusions here described in hornblende, as well as those mentioned beyond as occurring in the olivine, are identical with those which Professor J. W. Judd, of London, has recently treated with considerable detail in his paper on the Tertiary Peridotites of the Western Islands of Scotland. (Quarterly Journal of the Geological Society, vol. xli, p. 354, August, 1885.) This author considers all of the minute, indeterminable bodies which are so common in the feldspar, hypersthene, diallage, hornblende and olivine of the more basic ancient eruptive rocks as *secondary* in their origin. He thinks that at the great depths at which these rocks were probably formed, the pressure imparted to the circulating waters such an increased solvent action that cavities having the form of negative crystals were produced in certain crystallographic planes, similar to the well-known "ætzfiguren." Into these cavities he supposes certain ingredients, which had been leached out of the mineral or out of other minerals surrounding it, to have been deposited. To such a secondary process, which is almost always accompanied by the development of a glistening, bronzy luster on the planes in which the negative crystal cavities have been formed, Professor Judd applies the name "Schillerization." (l. c., p. 383.)

To the conclusion regarding the secondary formation of these well-known in-

total disappearance of the characteristic inclusions. The mineral becomes nearly colorless and consequently nonpleochroic while retaining the compact structure and optical behavior of the unaltered portion. Later there is developed, particularly around the edge of the hornblende, a bright, emerald green substance which on account of its lack of dichroism and very feeble action on polarized light may be regarded as chlorite.

Next to the hornblende the most important constituent of this rock is the *olivine*, which is remarkable both for its freshness and for its beautiful inclusions. It is present in rounded grains or in well defined crystals upon which the usual combination of domes, prism and pinacoids may be seen. These crystals vary from ½ to 2 mm. in diameter. The mineral is quite colorless, with a high index of refraction, and is traversed by irregular cracks along which serpentinization may frequently be seen to have commenced, although in many sections there is hardly a trace of this alteration. The inclusions in this olivine are quite similar to those which have been described in the olivine-gabbro from the island of Mull on the west coast of Scotland by Prof. Zirkel* and by Prof. Cohen in the so-called Hypersthenite from Palma.† They are black and opaque, having generally the form of minute, rounded grains or long rods ar-

clusions in the manner above described, the present writer would take exception on the following grounds:—

1st. It is by no means true that all crystals of the same mineral from the same locality, or even in the same specimen, always contain these inclusions in equal quantity. In the hypersthene of the Baltimore gabbros, for example, they are sometimes abundant, sometimes wholly wanting, and this is true even of individuals occurring side by side in the same thin section.

2d. Professor Judd's explanation is inconsistent with the frequent zonal arrangement of these inclusions. If they were formed subsequent to the solidification of their host, we should expect to find them uniformly distributed; on the contrary in the hornblende above described and in many feldspars they are concentrated toward the center or grouped in regular zones.

3d. It does not appear to be a fact that, as Professor Judd suggests, the minerals in which these inclusions are most abundant, are lighter in color or less strongly pleochroic than those without them. In sections of the Baltimore gabbros no difference could be observed by the writer between either the color or pleochroism of hypersthene crystals destitute of inclusions and such as were completely filled with them.

4th. The minerals in which the inclusions are most abundant are always extremely fresh in their appearance. At the commencement of anything like alteration they are the first things to disappear.

5th. Many inclusions of this class do act upon polarized light, indicating that they belong to definitely crystallized species.

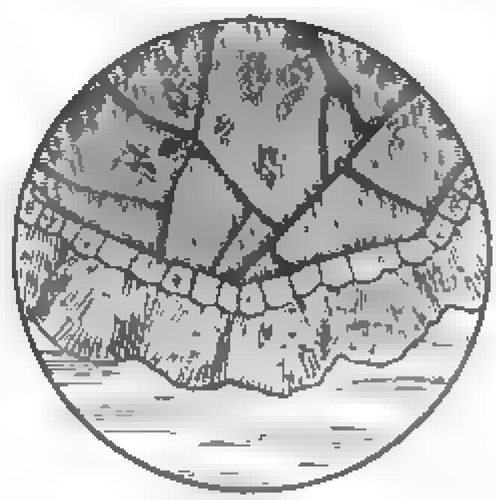
To the writer there seems every reason to regard the indications which produce "schillerization" as original in their nature. They appear to be composed of substances extruded from the rest during the process of its crystallization as incapable of forming a part of its chemical composition, not unlike the crystallization of certain impurities in limestone as various silicates, when the limestone undergoes metamorphism to marble.

* Zeitschrift der deutschen geologischen Gesellschaft, xxiii, 1871, p. 59, Pl. IV Fig. II. Mikrosk. Beschaffenheit, p. 214.

† Neues Jahrbuch für Min., etc., 1876, p. 750.

ranged parallel to one or more of the crystallographic axes of the olivine, although they are sometimes more irregular in their distribution. Frequently these rods, instead of being straight, are variously bent and twisted, exhibiting the forms of trichites in obsidians. In such cases they show a tendency to form elliptical groups resembling a fine arabesque, as figured by Zirkel. The same author has observed that while these inclusions are very characteristic of the olivine of the older rocks, they are never found in that of the younger basalts. I could not see that those occurring in the Cortlandt peridotite were ever translucent as stated by Zirkel and Rosenbusch for other localities. There seems little doubt that they are composed of magnetite, since they are readily decomposed by acid, and since such grains of olivine as contain them in abundance are attracted by the magnet.

Aside from the ordinary alteration of olivine to serpentine, which may be most instructively studied at every stage in the Cortlandt rocks, the most interesting phenomenon exhibited by this mineral is the beautiful development of reactionary rims or zones, wherever the olivine comes in contact with feldspar. This latter mineral is indeed no essential ingredient of the peridotites, but as already mentioned, they constantly show a tendency by its assumption to grade into olivine-gabbros and olivine-norites. Wherever olivine comes in contact with feldspar, no matter how fresh both of the minerals may be, there is always present between them a double zone, the inner portion, nearest the olivine, being composed of square grains of nearly colorless pyroxene and the outer one of tufts of radiating actinolite needles of a beautiful bluish-green color and strongly pleochroic. Certain slides in Professor Dana's collection from Stony Point show this structure in great perfection, (see figure). The interior band of pyroxene is here 0·07 mm. wide; the exterior one 0·15 mm. The same phenomenon has been described by Törnebohm in the olivine-hyperites from Ölme in Sweden* and is even more wonderfully developed in a coarse grained olivine-norite from the south shore of Lake St. John, Prov. Quebec, Canada.† So constant is the dependence of this zone upon the contact of the olivine and the feldspar, that it must be in some way due to a reaction between the substance of these two minerals, the resultant amphibole and



* Neues Jahrbuch für Min., etc., 1877, p. 383.
† Vid. F. D. Adams, Am. Naturalist, Nov., 1885, p. 1087.

pyroxene having an intermediate composition. So sharply c fined, however, are the crystals of this zone against the pe fectly fresh feldspar and olivine substance that it is difficult conceive of them as produced after the rock had entirely solic fied. They may have been formed by a reaction between the substances while at least one of them—the feldspar—was cry tallizing, although in some cases the formation of the actinoli seems to have continued after this time. In any event, a traces of this border around the olivine disappears the insta this mineral comes in contact with any other constituent tha the feldspar.

The pyroxene constituent of the peridotite from King's Fer appears to be for most part *hypersthene.* It sometimes forn small irregular grains not larger than those of the olivine, bu in other specimens it is present in individuals which are over centimeter in length, enclosing the smaller grains of both ol vine and hypersthene like the hornblende. In all forms possesses all the ordinary characteristics of hypersthene, e: cept that it is singularly free from the usual inclusions. I pleochroism is very strong: $\breve{a} = \mathfrak{a}$ ray, red; $\bar{b} = \mathfrak{b}$ ray, yellow $\acute{c} = \mathfrak{c}$ ray, green. Its cleavage is well developed parallel t the prism (∞P) and also still better parallel to the brachypin coid (∞P $\breve{\infty}$). Its orthorhombic character is proven by i parallel extinction and the appearance of a bisectrix when suc sections as are cut nearly perpendicular to the vertical axis ar examined in converging polarized light. A common, non-ple chroic *augite,* in which a diallage habit is frequently develope by the presence of a parting parallel to the orthopinacoid, also often to be observed in this rock, although in many spec mens it is altogether lacking. As this constituent increases importance the rocks grade into those of the next group.

The only remaining silicate which enters into the compo tion of the hornblendic peridotites is the *biotite.* This miner rarely retains its brown color. It is generally so complete bleached as strongly to resemble muscovite in thin sectio It is much bent and twisted, often having small lenses of ca cite interposed between its lamellæ, like those figured by I Hussak.* Aside from mere bleaching, the formation of t bright green, chloritic mineral, noticed as an alteration produ of the hornblende, is also frequent. The true character of th mica is revealed by its very small axial angle—the hyperbo being hardly seen to open at all when cleavage pieces are e amined in polarized light—as well as by the fact that rare sections may be found which have escaped the bleachi

* Anleitung zum Bestimmen der gesteinbildenden Mineralien, 1885, Taf. fig. 81.

These have the characteristic color and dichroism of biotite and sometimes contain acicular inclusions resembling the needles of rutile described by the writer in biotite from the Black Forest.*

Feldspar though frequently accessory, is never an important constituent of these rocks.

Magnetite, aside from composing the inclusions in the olivine above referred to, forms small grains which line the cracks in this mineral, and are especially abundant about its edge, where it is in contact with the brown hornblende. The large opaque grains scattered through the rock are almost all *pyrrhotite*, (magnetic pyrites (Fe_7S_8)); chromite or picotite were not observed; another form of spinel however, *pleonast*, recognized by its dark green color and isotropic character, is not uncommon. This mineral is filled with thin opaque plates almost exactly like the inclusions in the well-known *hercynite* from Ronsperg in Bohemia. *Apatite* was hardly ever observed.

2. Augite Peridotite.

Picrite (Tschermak).†

The true picrites of the Cortlandt Series are very closely related to the hornblende-peridotites just described. They are connected by a complete series of transitional stages in which the amount of hornblende becomes less and less, while a non-pleochroic augite, which under the microscope appears nearly colorless, is developed in proportion.

The best locality for the most typical picrite is near the eastern bank of the river on the south side of Montrose Point (No. 62). In this rock the brown hornblende, although still present in the form above described, is reduced both in amount and in the size of the individuals, while the augite reaches its maximum development. Montrose Point rises on the western side of the basin in which most of the Crugers brick-yards are situated, as a rather abrupt rocky wall. This is generally covered with a reddish, earthy deposit, due to the oxidation of the iron in the basic minerals of which it is composed. The rock, of which very fresh and unaltered specimens may be obtained near the river bank, is of a dark green color and of an even grain of medium coarseness. When examined with the unaided eye its most prominent feature is the glistening, black cleavage surfaces of hornblende. Small grains of magnetic pyrites and reddish spots indicating the former presence of an olivine crystal are abundant.

In a thin section under the microscope the hornblende, in spite of its prominence in the hand-specimen, is seen to be sub-

* Neues Jahrbuch für Min., Geol. und Pal., II. Beilage—Bd., p. 617.
† Sitzungsber. d. k. Akad. in Wien., 1866. Bd. xl, p. 113.

ordinate to the *pyroxene*. This mineral is chiefly represented by a nearly colorless augite, which frequently assumes the habit of diallage by the development of a pronounced parting parallel to the orthopinacoid. In spite of this, however, the inclusions so characteristic of diallage are, in all of this monoclinic pyroxene, almost wholly absent. This mineral can of course show no pleochroism when it is so nearly colorless. Twinning lamellæ parallel to the orthopinacoid are frequent, their boundary being often visible in ordinary light as a sharp line. The extinction angle in prismatic sections is in some instances as great as 40°. Cleavage fragments parallel to the orthopinacoid show in converged polarized light a single optical axis which remains nearly stationary in the field when the stage of the microscope is revolved.

Hypersthene, in all respects identical with that described as occurring in the hornblende peridotites, is common, but in no instance is it as abundant as the diallage. Very interesting instances of the parallel growth of these two minerals were observed where the orthopinacoids of both lie in the same plane. In some cases no line of demarcation could be seen between them, although the pleochroism of the hypersthene easily distinguished it from the diallage. A crystal of the latter mineral looks as though it had become red and pleochroic at one extremity or the other; but between crossed nicols the orthorhombic character of this pleochroic portion is very apparent and in great contrast with the high extinction angle of the diallage.

The *hornblende* is likewise quite identical with that already described. It is, however, much reduced in amount and in the size of the individuals. In the abundance of its inclusions it forms a contrast to both of the pyroxenic constituents.

The *olivine* shows no peculiarities which have not been already noted. It is not present in large amount but forms comparatively sharply defined crystals, scattered at intervals among the other constituents. It is often extremely fresh but in other cases completely changed to a yellow, isotropic serpentine.

Considerable *magnetite* is readily extracted from the powder of this rock with a magnet. Neither apatite nor feldspar were observed in the sections of the Montrose Point rock.

Another rock almost identical with the one just described from Montrose Point was collected about 135 yards west of Munger's near Montrose station on the N. Y. C. R. R. (No. 46.)*

Still another specimen (No. 54), which belongs to this type was obtained near the house of Mr. Butler, on the road leading from Montrose Point to Montrose Station. It represents a

* Mentioned by Prof. Dana in this Journal, Sept., 1880, at the foot of page 217

member of the extremely interesting section exposed here for 150 feet and described by Professor Dana in his paper on the Limestone belts of Westchester County.* The rocks here vary considerably in their mineralogical composition at different points. They are for the most part quite massive but not infrequently they exhibit signs of a schistose structure. This Professor Dana was inclined to attribute to only partially obliterated stratification planes; but a microscopic study of the rocks in question shows most conclusively that the structure is one which was secondarily developed in massive rocks by the action of great pressure. Scarcely any specimen is better calculated to show the effects of such action on the minute internal structure than the above mentioned No. 54. The minerals present are diallage, hypersthene, brown hornblende and a little olivine. The principal constituent is diallage in large rounded individuals which are frequently twinned and always possessed of that peculiar, finely striated (almost fibrous) appearance, which is well known to be the result of pressure.† These diallage crystals are often bent and, no matter what may be their crystallographic orientation, it can be seen that for all the pressure acted from one constant direction. Around these diallage individuals, and occasional hypersthene crystals which have been subjected to like influences, extend finely granular, curving bands of secondary pyroxene and brown hornblende. This granular aggregate encloses the large, rounded and bent pyroxene crystals like a groundmass and produces a structure similar to that seen on a larger scale in the "augen-gneiss."‡ Such fine-grained aggregates of secondary minerals enclosing the remains of larger original crystals have been admirably described and illustrated by Professor J. Lehmann§ in the "Augen-gneisses, granulites and "Flaser-gabbros" of Saxony and by Professor K. A. Lossen‖ in the metamorphosed diabases of the Harz Mountains.

It is a fact not without significance in the case before us that brown hornblende is a very abundant constituent of the secondary groundmass while it appears to be lacking among the original constituents, although the larger individuals of diallage appear in some cases to be passing into it by paramorphism.

Two sections of Professor Dana's collection marked St. 3 (D)

* This Journal, Sept., 1880, p. 218.

† Vid. O. Mügge, Neues Jahrbuch für Min., Geol. u. Pal., 1883, i, p. 84, and van Werveke, ib., ii, p. 99.

‡ For the German term for this structure: "*flaserige* or *mikroflaserige Struktur*" there seems to be no exact English equivalent. It is common in the gneisses and is sometimes called lenticular structure. The term "*flaser-structure*" might be adopted for it from the German.

§ Untersuchungen über die Entstehung der altkrystallinischen Schiefergesteine. Bonn, 1884.

‖ Jahrbuch der kön. preuss. geologischen Landesanstalt für 1883, p. 619.

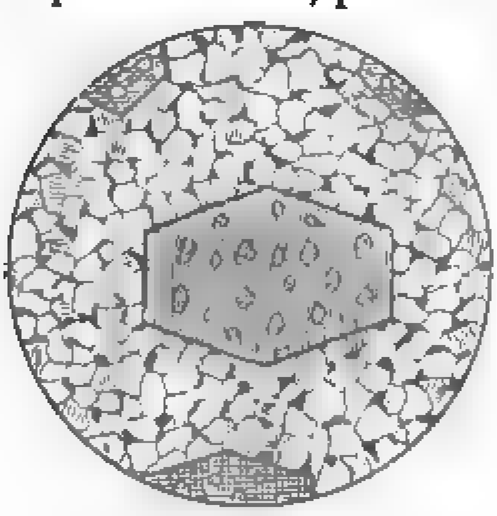
and St. 6 (D) belong to this class of picrites. A chemic sis of the rock (No. 62) from the south side of Montros was made by Mr. W. H. Emerson in the laboratory of th Hopkins University with the following result:—

SiO_2	47·41	
Al_2O_3	6·39	
Fe_2O_3	7·06	
FeO	4·80	
CaO	14·32	
MgO	15·34	
Na_2O	·69	(determined by di
K_2O	1·40	
H_2O	2·10	
S	·49	
	100·00	

Specific gravity = 3·30 at 15° C.

The sulphur may be referred to pyrrhotite. The high gravity and the percentage of ferric iron present indicat siderable amount of magnetite. The almost equal quar lime and magnesia prove that neither hypersthene nor can be largely represented among the constituents. Tl will be seen at once to be too high for a typical peridot fact all the most basic rocks of the Cortlandt Series whi come under the writer's notice are too acid to be cla representative olivine-rocks. This manifests itself, as rocks here described, in the relatively small amount of associated with the pyroxenic constituents or in their te to develop feldspar and so form transitions to olivine- and norites.

A rock, which is quite common on the northern side o Point and also to be met with at several localities in th ship of Cortlandt, possesses a composition intermediate the hornblende-peridotite a picrite. The groundmass rock is a moderately fine- gray colored aggregate co principally of diallage wit hypersthene and olivine. I sponds quite closely to the Imbedded in this are sharply crystals of black hornblen one to two centimeters in d These are short prismatic in being terminated at both end



dome faces so as to give cross-sections as shown in the They are porphyritically scattered through the gray grou

netimes very abundantly, and produce a curiously mottled ;k which is striking in appearance. These hornblende ;stals are themselves filled with inclusions of the other contuents, just as are the irregularly shaped hornblendes of the rnblende-peridotite. (Specimens No. 94 from Stony Point d No. 121 from the center of Cortlandt township.)

The rocks treated of in this paper, though all non-feldspathic d olivinitic and hence properly coming under the definion of peridotite, are very closely allied to a large and important group in the Cortlandt Series from which both feldspar id olivine are absent. Especially on the northern side of ;ontrose Point curious and unusual massive rocks occur, comnsed only of augite, diallage, hypersthene, brown hornblende nd a little biotite. These constituents are present in every onceivable size and proportion. Professor Dana has designaed these rocks as hornblendytes and pyroxenytes.* The ;riter hopes to communicate the results of a microscopic study f them, together with the gabbros and norites of the Cortlandt ;eries, in a later paper.

Petrographical Laboratory of the Johns Hopkins University, Oct. 15, 1885.

ART. V.—*Description of a Meteorite from Green County, Tennessee;* by WM. P. BLAKE.

THE meteoric iron, of which the following is a description, as found by a farmer ploughing his field, in Green County, 'ennessee. It was completely buried in the earth and there is o knowledge of the time of its fall. In the year 1876 it was ent by General J. T. Wilder with the minerals of Tennessee o the International Exhibition at Philadelphia, and has since een in the writer's collection at New Haven. The weight of he mass is 290 pounds, equivalent to 639·36 kilograms. The riginal weight is said to have been 300 pounds. It has been essened by small portions cut from the ends of the iron and y exfoliation.

The form of this iron is its most striking visible peculiarity, eing an extremely regular long ellipsoid, tapering at each end o a flattened point, but having throughout its length an ellipoidal section. It has been compared in shape to a flattened ;igar. The form and general appearance of the mass are, however, shown by the accompanying illustrations. Figure 1, a top view of the broadest surface, from a photograph, and figure 2 an outline of the side view.

The dimensions of this meteorite are:

* This Journal, Sept., 1880, pp. 197, 198.

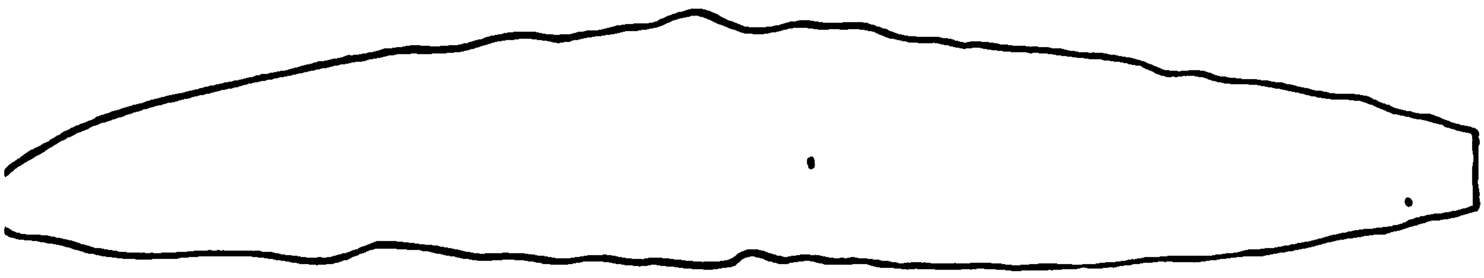
	Inches.	Meter.
Length	36	·9144
Breadth	10	·2540
Thickness	6	·1524
Girth	24	·5991

The cutting off of small fragments from each end before it came into my possession has, apparently, reduced the original length three, or possibly as much as six, inches, assuming that the mass was prolonged in the direction of the remaining surfaces.

The surface is scaly and rusty, but is in general smooth and evenly curved, with the exception of several cup-shaped indentations or depressions, one of which, near one edge, gives the inward curvature in the elliptical outline seen in fig. 1. One of the depressions is nearly three inches broad and an inch in depth. So far as the examination of the mass has extended, the interior not having yet been laid open to view, these depressions do not appear to be due to the weathering out of more or less globular inclusions, such as troilite or schreibersite, but rather to the unequal exfoliation. The mass when struck by a hammer is remarkably sonorous and seems to be very compact and sound throughout.

This meteorite clearly belongs to the class of exfoliating deliquescent irons, several examples of which have been found in Tennessee and the adjacent States of Georgia and North Carolina. The oxidized crust is in some places very thin and a few strokes of a file develops the unchanged bright iron below, but in other parts of the mass the crust has been found to be much thicker, especially after the meteorite has stood unmoved for several years. Flakes as broad as the hand, and nearly one-quarter of an inch in

hickness, have then been scaled off from the lower side. This scaling is the result of the gradual oxidation of he surface of the iron by the deliquescence of included



iron protochloride—lawrencite of Daubrée—as shown by the abundant reactions for chlorine and the constant accumulation of moisture, especially upon the under surface of the iron. This deliquescence has for years been sufficient to cause drops of perchloride of iron to form and fall off at times upon the support below. The heavier of the oxidized crusts exhibit thin successive layers with smooth mammillated surfaces like the surface of limonite. They consist of a mixture of hydrous sesquioxide of iron and magnetic oxide. They affect the magnetic needle and exhibit feeble polarity as some fragments of the bright iron also do, but this may be in consequence of the invisible presence of a scale of the magnetic oxide. The exudation of moisture appears to be greatest from small seams, which on cutting into the iron are found to extend for half an inch or more below the surface and are filled up with dark and hard magnetic oxide. Freshly cut surfaces of the iron, when laid upon a sheet of white paper, soon cause rusty spots, and moisture accumulates upon the surface, particularly in damp weather. We have perhaps in this constant exfoliation of the mass an explanation of its peculiar symmetrical form. It may be regarded as the kernel or residuary nodule of a much larger and probably a much more irregularly shaped mass, the gradual exfoliation having thrown off the irregular projections leaving, finally, the symmetrical core.

For the examination of the internal structure and chemical composition a slice a few ounces in weight was cut from one end. The iron is readily cut by a saw with oil and it works well under a file, giving a uniform dense surface without any signs of inclusions or of crystalline structure. If a fragment is sawn partly across and is then struck a strong sharp blow a fracture is obtained and exhibits a fine granular surface like some fine grades of cast steel, but no crystalline facets are visible. It is perfectly malleable. Thin, fin shaped projections may be bent back and forth repeatedly without cracking. A fragment heated to redness and quenched in cold water is not perceptibly hardened, and may be, as before, spread into thin sheets under the hammer. Its malleability is not impaired.

The metal takes a high mirror-like polish. The only imperfections seen are the occasional seams of magnetic oxide which probably will not be found in portions taken from the interior of the mass. The polished surface treated with nitric acid fails to show any structural markings, and the etching of a cuboidal mass with polished plane surfaces at various angles gives a like negative result. The iron dissolves equally on all sides leaving a delicate velvety or frosted surface indicating a very even and fine granular structure. In polishing, the use of a burnisher must be avoided for the lines of unequal condensation will appear in the etched surface. The dull soft surface left by etching has a silvery gray color and yields quickly to the burnisher and becomes mirror-like. The specific gravity of the iron at 60° F. taken upon a cuboidal mass dressed with a file to remove all scale was found to be 7·858, but subsequent solution showed that there was a very small amount of included scale.

A qualitative examination showed the presence of iron, nickel and chlorine. A special examination for phosphorus was not undertaken. No satisfactory reaction for cobalt could be obtained. Hydrogen is probably occluded, but no test for it was made. A more complete chemical examination is intended upon a portion taken from the midst of the mass. A quantitative determination of the iron and the nickel by the method recommended by Baumhauer gave me in per cents:

Iron	91·421
Nickel	7·955
	99·376

The solution of the iron in pure cold nitric acid develope some hidden peculiarities. A gray heavy metallic powder i thrown off as the solution progresses and accumulates at th bottom of the beaker. This powder when separated by decan tation and washing is found to be in distinct grains and resem bles finely divided metallic nickel, which is its dominatin constituent. It remains apparently unacted on by the nitri acid, while the solution of the parent source is progressin rapidly. Exposed to the air, even while moist, it does not ap pear to oxidize. It is very malleable, and when pressed in smooth agate mortar with the polished end of the pestle it flatter and covers the surface as if with a sheet of silver. It dissolve quickly in hot nitric acid, and gives a green solution and th reactions for nickel and for iron also. The quantity vari with the temperature and strength of the nitric acid used. I one trial about five per cent. was obtained. In another th grains were in the form of spiculæ, the length being great

than the breadth. In composition it is an alloy or mixture of nickel and iron with the nickel in larger quantity relatively to the iron than in the mass.

This deportment in acid indicates the diffusion of granules of a nickel alloy less soluble than the bulk of the iron. It is possible however that the separation of these grains may be the result of mechanical action attending rapid solution, and the evolution of gas disintegrating the iron, producing small grains, from the surface of which the iron is dissolved faster than the nickel. Either view of the origin of the granules sustains the conclusion that this meteoric iron has a granular structure, which is but another phase of the still unexplained phenomena of the aggregation, or structure, of meteoric irons, whether they are distinctly crystalline or are made up of layers differing in composition. The granular condition is more like that of electrolytic iron than the crystalline or banded forms and it may be regarded as lending additional support to the theory of electrical deposition.

Compared with some other meteoric irons with oxidized surfaces it is found to resemble the iron from Dalton, Whitfield County, Georgia, now in the collection of Professor Shepard. This meteorite has a brown and scaly coating but the iron has traces of geometrical structure. It is stated that when this Dalton meteorite was found, one mass of iron was sent off to Cleveland, Tennessee, and has since been lost sight of. Another meteorite from Green County, Tennessee, is described as having an oval flattened form with a coating of specular iron penetrating for half an inch or more the mass of iron. Specific gravity 7·43. No crystalline structure and no nickel was found, but three per cent of carbon, chromium, and tin.* Except in composition and gravity this iron compares closely with the subject of this paper.

According to Prof. Shepard, a meteorite from Green Co., Tenn., contains 14·7 per cent of nickel.† The Tazewell County, Tennessee, meteorite, in which the late Prof. J. Lawrence Smith found solid protochlorid of iron was oxidized in some places one quarter of an inch deep. It exhibits crystalline structure and contains 15 per cent of nickel. Gr. 7·88.‡

The iron of Campbell Co., Tennessee, also attracts moisture and exhibits regular crystalline figures. According to Willett§ an iron from Putnam Co., Georgia, was covered with a brown scaly crust, and freshly cut surfaces soon became moist with drops of a liquid supposed to be chlorid of iron. Structure became visible by etching.

* This Journal, xvii, 329.
† Ibid, vol. xvii, p. 327.
‡ Ibid, xvii, p. 137.
§ Ibid, xvii, 331.

Being unable at present to give further attention to the investigation of the internal structure and peculiarities of this meteorite, it has been transferred to Mr. Geo. F. Kunz, who will probably have it cut up for investigation and distribution.

Mill Rock. New Haven, Oct. 1, 1885.

ART. VI.—*Tendril Movements in Cucurbita maxima and C. Pepo*; by D. P. PENHALLOW. With Plate V.

IN the summer of 1874, certain experiments were made with reference to the mechanical energy with which the organization of tissues is effected, as illustrated in the lifting power of the mammoth squash.* During the same and following years, as suggested not only by these experiments, but more particularly by Darwin's paper on Climbing Plants in the Journal of the Linnean Society for 1865, I undertook to study the movements of the squash tendrils and terminal bud, and trace the relation of these phenomena to meteorological and other conditions of growth, in order to determine if possible, a rational solution of a question at that time not at all well understood, except in its more external aspects, as studied by Sachs, De Vries and Darwin. At that time it was recognized that plants possess no nervous system, yet phenomena were continually observed which were wholly inexplicable upon any other ground than that the plant must possess something akin to nerves. At that time also, it was regarded as fully demonstrated that each protoplasmic mass of a cell is a unit within itself, its limitations being determined by the surrounding cell wall.

The observations which I then made upon tendril movement have never been published, though the results were fully worked out five years since. Publication was withheld in the hopes that at no distant day, the correct solution of certain phenomena, which could not then be satisfactorily accounted for, might be reached.

The very important discoveries of the past few years, touching the continuity of protoplasm, served to give a clue which has been followed up during the past summer with the results that the true explanation of the tendril movement in *Cucurbita* and possibly also in the whole family *Cucurbitaceæ*, appears to have been reached from histological research, and we now feel justified in presenting the facts obtained, more especially as they will doubtless tend to enlarge an already rapidly widening field for observation.

* Phenomena of Plant Life: Clark.

Darwin has shown in his several works, in a very careful and ainstaking manner, how the movements of plants are produced modified in certain organs by various mechanical influences, s well as by natural conditions to which plants are ordinarily ubjected. He has also shown us what direction these move-ents take and the figures they describe, and to his first paper n Climbing Plants, in the Journal of the Linnæan Society for 865, was due the suggestion that, if these movements are but ormal manifestations of growth, dependent upon the perfect naintenance of the vital condition of the plant, they must ecessarily be affected by whatever operates in any manner—whether to augment or diminish—the physiological changes in, and conditions of the plant as a whole; and, therefore, that they must afford a ready means of determining the effect of varying meteorological conditions upon growth, and those which are best adapted to its promotion. It was, therefore, with this idea in mind, that the experiments here recorded were undertaken. It was recognized as of prime importance that, to secure results which should be of the greatest value, the plants must be grown in the open air and under the varying conditions to which they would be naturally subjected. It was also thought desirable to select a plant of vigorous growth, in which movements were sufficiently pronounced and rapid to permit of frequent and accurate observation. The mammoth squash (*Cucurbita maxima*) was found to answer the requirements better than any other plant obtainable. With this, all the original experiments were obtained, but during the past summer, *C. pepo* was used for the purpose of confirmation and to gain information upon one or two additional points of minor importance. This was possible, since the structure of the tendrils and also their movements are the same in each case, so that our remarks may apply equally well to both species, and doubtless to a very large extent, to the entire family.

Seeds of the mammoth squash were planted in a carefully prepared lot, sufficiently removed from trees and buildings to prevent the plant being subject to any but the normal conditions of light, air, temperature and moisture. As soon as the vines were long enough, they were carefully trained from west to east, their branches being allowed to run in whatever direction they might choose. The tendrils, upon which observations were made, were in some cases selected as soon as they became straight and active, in other cases not until they had been moving for some hours or perhaps a day. The aim, however, was to record the movements for as many consecutive hours of night and day, during the entire period of growth, as possible. Through variation in movement of the tendrils and terminal bud, rate of growth in the vine and weight of the

squash, a knowledge of the conditions favorable and adverse to growth was sought. To accomplish this satisfactorily, observations were made through day and night for one week, at least once each hour, generally at much more frequent intervals, and every observation recorded was accompanied by record of local* temperature, humidity, cloud, condition of the plant, etc., etc.

The method of recording the tendril movements was as follows:—

A board made two feet square, was provided with two pointed legs by means of which—thrusting them into the ground—it could be securely fixed in a vertical position. Upon the board there were fastened several sheets of heavy white paper, so arranged that each could be removed in turn, without disturbing the position of the board, (fig. 1). The recording board thus prepared was then firmly fixed in a position at right angles to the horizontal tendril. To prevent any accidental movemen[t] of the latter from its proper position, a stake was driven by the side of the vine at the node from which the tendril arose, an[d] the plant was then secured firmly to it. With the tip of the tendril only one-fourth of an inch from the surface of the paper it was an easy matter to mark the position at any time with a pencil. The position was noted whenever, from the rate of movement and distance traveled, it was thought a change of direction was about to occur. In this way the observations were made at varying intervals, sometimes of one hour, some times of only one-half a minute, and many, originally taken were finally eliminated from the results whenever they fell in the same straight line. The time was always carefully noted as also all conditions of atmosphere and of the plant which might have a possible bearing upon the movement.

Tendrils.

The tendrils of the squash are modified leaves,† and are placed alternately opposite, an arrangement well adapted to bring the plant between secure but elastic supports on either side. They are composed of four or five long and slender filaments—wholly devoid of external appendages by means of which they can become attached to objects—borne upon a stout stalk or petiole of from 6 to 10^{cm} in length. The arms are of very unequal length. In vigorous vines the longest arm which is the first to develop, often exceeds 30^{cm} in length. The extreme lengths of vigorously moving tendrils may gene[r-]

* The temperatures were taken from a thermometer hung by the side of the plant two feet above the ground.

† The exact morphological nature of the tendril in Cucurbitaceae is still a matter of some [illegible] regarded as a modified leaf, stipule or branch. [illegible] in each of these views may be adduced.

ally be taken at from 8^{cm} when they first emerge from the bud condition, to 35^{cm} when activity ceases.

At first rolled up compactly as they come from the bud, with the coils turned inward, the arms gradually extend to their full length, and, within two days, activity begins in the central arm while those which are lateral may yet be loosely coiled. After motion once commences, the order of activity is from the center outward, until all are involved. In this we see one of those curiously interesting provisions of nature for the accomplishment of her plans. If all the tendril arms were of the same length, or, more important, became equally active at the same time, the express purpose for which they were provided, would fail of accomplishment in nine cases out of ten. As it is, their activity extends over a considerable period, and the first one in motion may have grasped an object, or, failing, have become hard and inactive, long before the last gets fairly in motion. It is the function of the tendril to draw the vine to a secure and elastic support. By the succession of activity here exhibited, one arm after another is enabled to grasp the object of support and gradually draw the vine up to a secure position; whereas, by a simultaneous activity of all, a few only might gain hold, or, if all, only the last one or two would bear all the strain, and the vine would remain at a greater distance from the point of support.

Histology of the Tendril.

In its histological aspects, the tendril of the squash vine presents a most interesting study, and throws much light upon the cause of the movement; indeed, it is to evidence of this character that we must chiefly look for a true solution of this question. We shall consider this part of our discussion under two heads: (*a.*) Structure and peculiarity of component tissues in their mutual relations, and (*b.*) Continuity of protoplasm.

(*a*) Transverse sections of the tendril display the form and general structure which is shown in fig. 3. From this it will be seen that within the fundamental structure there are seven fibro-vascular bundles, the largest of which are along the lower side of the section and therefore traverse the lower region of the tendril arm through its entire length. A more detailed examination discloses several important facts. Directly beneath the continuous epidermis of one row of cells, there is a somewhat thick layer of collenchyma tissue (fig. 3 *a*), extending completely round the tendril with the exception of three regions where its continuity is fully interrupted by parenchyma tissue (fig. 3 *b*). These areas of interruption are found to occupy the same relative positions in all squash tendrils;

one lies in the concavity of the upper surface, while the other two occupy lateral positions, being situated at the extremities of the major axis of the section. Within these areas (fig. 3 *b*, *b'*, *b''*), the tissue is found to be composed of rather large and rounded, somewhat thin-walled, parenchyma cells (fig. 5) containing protoplasm and a large amount of chlorophyll, while there are also inter-cellular spaces and corresponding stomata in the epidermis. Externally this tissue may easily be seen to extend the entire length of the tendril, forming three darker green bands alternating with the more whitish green bands of collenchyma tissue. The color distinction between them is most obvious, both externally and in transverse section. From the very prominent part which this tissue takes in the ordinary circummutations of the tendril and the frequency with which pointed reference must be made to it, we have deemed a descriptive term essential. We have therefore given it the name of *vibrogen*, or as signifying that the origin of the movement is to be found there. Immediately within the collenchyma layer is a zone of rather large and rounded parenchyma cells (*c*, fig. 3) consisting of three or four rows, the innermost cells being smaller. This tissue connects the three vibrogen bands through their inner portions. The cells are filled with protoplasm, chlorophyll and other granular matter, though the chlorophyll is conspicuously less than in the three bands of vibrogen which it unites with. It is this layer of cells, however, which imparts the green color to the tendril as a whole, modified as it is by the external layer of collenchyma. Directly interior to this zone is a narrow belt, within which the fundamental tissue becomes meristomatic at a very early period, and ultimately—usually very early in the growth of the tendril—gives rise to numerous rather small and thin-walled wood cells (fig. 3 *d*, *d'*, *d''*). In the earlier periods of growth, this wood tissue will be found forming a crescent along the lower side of the transverse section, as at *d*, but later, toward the left of the tendril, it arises opposite the two masses of collenchyma tissue near the upper side *d'*, *d''*, its interruption or want of continuity coinciding exactly with the want of continuity in the collenchyma, or with the position of the vibrogen tissues. Ultimately, however, these breaks may close up, and the woody zone then becomes more or less continuous around the entire tendril. So long as the tendril arm remains active, these wood cells are thin-walled (fig. 4 A), but as age advances and activity diminishes, the wood cells are found to become thicker and more resisting and finally assume the appearance of all highly lignified cells (fig. 4 B), thus ultimately defining the hard and woody nature so characteristic of these tendrils ,after they have been for some time coiled about a support.

Interior to the wood zone is the remaining portion of the fundamental tissue. In the outer portion of this, the vascular bundles already referred to arise, while the inner portion remains as a pith region and often shrinks away from the center, developing a lysigenetic air cavity, thus leaving the basal portion of the tendril arm like the petiole from which it arises, hollow.

That these various tissues bear an important relation to the movement of the tendril and its power to grasp an object or coil up without contact, is most certain, and what these relations are will be seen after we have considered the motions themselves.

We should also remark, in passing, that this structure is not peculiar to the tendril arm, since in all its essential features, i. e., collenchyma, vibrogen and woody tissue, the same structure is to be observed in the petioles of both tendrils and normal leaves, with this difference, however, that in these latter, the vibrogen is found in more than three bands, and these are arranged at tolerably regular intervals about the circumference of the petiole.

(*b.*) The recent developments concerning the continuity of protoplasm in vegetable tissues, at once served as a suggestion that in active tendrils this continuity should be found, if anywhere, and that it must doubtless furnish an important clue to the proper explanation of many phenomena connected with movement of the tendril itself.

Thin transverse sections of the tendril were treated upon a glass slide while yet quite fresh, with concentrated sulphuric acid for a period of two or three seconds, at the end of which time they were quickly immersed in water and thoroughly washed to remove all acid. Care must be taken not to allow the action of the acid to proceed too far, or both structure and protoplasm will be destroyed. If successful, the cell walls should be strongly swollen, but not broken.

After washing in water, the sections were stained in picric aniline blue,* being allowed to lie in the stain for ten minutes. At the end of this time they were thoroughly washed to remove all the picric acid, as is indicated by the failure to discharge any more yellow, and a change of color in the sections to a well-defined blue. The results are best when the alcohol washing succeeds in removing all the picric aniline from the cell walls, but leaves a maximum of aniline-blue in the protoplasm. At the end of this treatment the sections were mounted in 25 per cent glycerine for examination.

* This is essentially the stain recommended by Gardiner (Phil. Trans., 1883, p. 817), and was prepared by saturating a 50 per cent solution of alcohol with picric acid. To this add BB blue until a *dark* greenish blue solution is produced.

For permanent preservation, the sections may be mounted directly in glycerine jelly, or they may be washed out in water, cleared up for a few seconds in concentrated carbolic acid* and then mounted in chloroform balsam. Either method gives very satisfactory preparations, though the former is preferable.

The results obtained by this process are most satisfactory, particularly in the collenchyma tissue (fig. 6). There the walls become strongly swollen, and the protoplasmic connections are sharply defined as blue threads running through the colorless walls (fig. 7). Salt solution does not give so satisfactory results, through its failure to properly swell the cell wall, which is essential, while on the other hand, the cellulose reaction developed in the collenchyma under the action of chlor-iodide of zinc, renders this process of little value in this particular case, as there is then too little distinction between the blue filaments and the blue cellulose of the cell wall.

It is thus clearly demonstrated that there is a distinct continuity of protoplasm through the living tissues of the tendril, particularly in the collenchyma (fig. 7), and this must have an important bearing upon the transmission of impulses, e. g., those produced by irritation, from one portion to another.

Externally, the form of the tendril arm is that of a long filament, well-rounded on the lower side, but flattened and even slightly channeled above. The extremity, for a distance of half or three-quarters of an inch, takes a more perfectly rounded form and turns slightly downward, the concave side of the curve being that which is always the more sensitive. The lower surface, which is almost entirely free from epidermal hairs, is always the most sensitive to contact, curvature being readily produced by contact of the finger with it, though the same effect is not produced upon irritating the upper side. A curve in one direction as the result of irritation, is removed only after the lapse of some little time, when, by continued growth, the opposite sides become equal in length. The lower side is the one which, in the majority of cases, first comes in contact with an object of support, and in any case, it is finally the side toward which the bending most strongly tends.

In one case, a tendril irritated on the lower side by the finger coiled upon itself completely in one minute. The cause of irritation removed, the tendril straightens out again, provided it is not already too far advanced in age, or the irritation is not too long continued. Slight pressure such as would be caused by small loops of thread, also often exert a definite influence

* Phenol used in this way gives most satisfactory results as a clearing reagent and for a long time has with us, replaced turpentine entirely. Jour. Royal M. S. Soc., vol. iii, pp. 693 and 858.

irritation on the upper side, near the tip, produces a curvature through the central region of the arm, with the concavity uppermost, showing in this, a distinct transmission of the impulse to somewhat remote parts. A sharp blow on the upper surface, as with a pencil, throws the arm into a series of long undulations. Whenever the irritation is quite local, the resulting flexure is abrupt, but the curve becomes longer in proportion as the irritating body is moved over a greater length, thus showing that the impulses of this character are not readily transmitted.

During the entire movement of the tendril, distinct torsions are developed, as may readily be seen by following one of the lines of vibrogen tissue. Oftentimes the torsion is developed to such a degree as to turn the tip fully one-half revolution, thus making it apparently bend upward instead of downward. This fact is one which has all the more significance from the statement of Sachs* that in *Cucurbitaceæ* "no torsion takes place." Repeated observations, however, have fully confirmed its correctness. That this torsion bears an important relation to the circumnutation cannot be doubted, and what its connection is, will be seen later.

When in its circumnutating, the tendril arm comes in contact with an object, it immediately twines about it and grasps it firmly, the basal portion at length forming a double, reversed spiral, which draws more and more closely, and thus secures the plant more firmly to its support. It then rapidly becomes more and more hard and woody. Frequently the tendrils coil about themselves or other tendrils, or catching upon the edge of a leaf, they bend it under into close rolls, which increase in size as the coiling of the tendril progresses. Failing to secure an object of support, the tendril at length coils up in an irregular, knotted spiral, drops downward and either decays or gradually dries up and becomes hard and woody.

The woody character, which the tendrils assume in the end, is by no means to be regarded as the result of contact or other mechanical influence, but it is a natural change which necessarily follows from the structural elements of the tendril, as will be seen later; therefore, this serves to supplement, and give additional force to, other changes relating more especially to the former.

The figure described by the nutating tip is approximately ellipsoidal, the major axis being horizontal, (fig. 2). This axis not infrequently reaches a length of 24 to 27^{cm}; that of the minor axis being from 13 to 22^{cm}. In *Echinocystis lobata*, the diameter of the figure, according to Darwin, is even larger than this, measuring from 38 to 41^{cm}.† While the tendril

* Text Book, p. 866. † Climbing Plants, pp. 128–129.

describes a figure, the vertical plane of which is parallel w the axis of the plant, the space through which the tip move greatly augmented by a supplementary movement in the gr ing end of the vine, on which the tendril is found. This ondary movement causes the tendril tip to describe a dou movement which increases the possibility of contact with rounding objects.* It is of short duration, however, since movement of the vine is confined to the few internodes at end, and at any one node, continues for about two days o after the tendrils are in motion; so that by the time the first of the latter has grasped a support, the movement of the v at that particular node may have ceased entirely. So long there is no contact with a suitable support, which must be size easily grasped by the coils, the tendril continues to revo until a gradual increase of woody tissue arrests its activ Toward the close of its movements, the tendril often fall the ground and remains there for some time, or commence coil upon itself, only to straighten out once more and res its nutations. This may happen several times at decrea intervals as the tendril grows older, until finally, the wh arm coils upon itself in a simple spiral with the coils turn outward, becomes hard and woody and its functions then ce entirely.†

When brought in contact with an object near the tip, latter, at once affected by the irritation, coils about the supp with a firm grasp. The effect of irritation does not im diately extend along the remainder of the tendril, as is sho by the fact that when the tip is brought into contact, the b portion of the tendril continues its movement and passes by a curve, the sensitive surface, thereby becoming convex inst of concave, as would occur if it felt the influence of cont After a time, however, the effect of contact extends to all cells of the basal portion, which then draws itself into a cl and closer spiral. When a tendril comes in contact with object, it does not immediately lose its power of nutation, retains it for a very considerable period, and this is largely pendent upon and influenced by the age of the organ, retent being longer in the young and vigorous than in the more ag It becomes apparent, therefore, that when the tip is arrest

* The fact that there is this double motion as a resultant of tendril vine act shows that the true figure is to be obtained only when the tendril revolves al the inner surface of a glass globe and the changes of direction are recorded f the outside. This, however, was not practicable in our case, nor was it essen to the accuracy of the conclusions to be obtained, as will be seen later. For purpose, the plane recording surface was amply sufficient.

† My observations upon this point confirm those of Darwin with regard to o members of *Cucurbitaceæ*, that when a spiral is developed freely, it is alw simple; that it only reverses when the tip is attached to a support.

the bands of growth still continue to act in the basal portion, and still tend to bow the tendril alternately in all directions. Their power to do so is necessarily modified by fixation of the tip, and the natural result would be for the base to pass by the support as a curve, with the sensitive side outermost, and then develop torsion. These changes we find to occur from the beginning. If the coiling were primarily due to irritation, then we should expect to find the coil first developed as the result of simple contraction on one side, and this would not immediately give rise to torsion. The spiral formed in one direction after a time reverses itself as a natural result of excessive torsion in one direction, as Darwin has already proved,* and there is thus completed a double spiral spring, which draws more and more closely, becomes hard and woody after a time, and holds the plant to a strong but elastic support. How useful this arrangement is, may be readily seen during a strong wind when, under its influence, the plant is forced this way and that, in danger of being torn and broken. The springs then yield just enough to relieve the strain and avoid the possibility of danger. It was frequently noticed that, while corn and other plants offering much resistance to strong winds, were torn badly, the squash always came out whole.

During its active period, the tendril arm elongates rapidly, and the cessation of movement and of growth in length are simultaneous. From a series of measurements made, the following data were obtained. An arm just uncoiled from the bud measured 12^{cm} in length. One day later it had increased to 14·8^{cm}, and on the following day to 18·3^{cm}, thus giving a total increase in length of 6·3^{cm}, or one-half its original length. August 8th, five tendrils but a short time in action, were carefully measured and marked. The Monday following, 10th, all except one were found to have coiled about themselves or other objects. The coils were drawn out as fully as possible and measurements taken, but even then, the full length could not be obtained. The measurements were as follows:

	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.
August 8th,	12· cm	12·4	17·7	10·4	17·5
August 10th,	24·5	19·0+	25·0+	20·5+	33·0+
Gain,	12·5	6·6	7·3	10·1	15·5
Add for coils,	....	1·0	3·0	5·0	1·0
Total gain,	12·5	7·6	10·3	15·1	16·5

Thus we find the extreme range in elongation to be from one-half of to the same length as the tendril when it first

* Climbing Plants, p. 163.

emerges from the bud condition, and the mean ratio of incr (to original length) would be as 1: 1·14, showing that the dril practically doubles its length during the period of circ nutation. This, taken in connection with previous facts, hı striking significance.

The movement of the arm is not the only motion to be served in the tendril as a whole. It does not require a ı critical inspection to show that the same torsion which is veloped in the arm, is also produced as conspicuously in petiole from which it springs, and, as Miss G. E. Cooley* demonstrated, the torsion is associated with a well-defined cumnutation of the petiole, independently of the movement its arms.† By inserting a fine glass filament, with a blacke bead at its end, into the extremity of the petiole between arms, she clearly showed that the resulting figure correspc closely with that of an arm, when the two were in the sa line of extension, but differed when the tendril arm turned at right angles to its petiole.

From structural considerations, we felt also justified in (cluding that the leaf tip must perform a circumnutation sim to that of the tendril itself. This Miss Cooley also den strated to be a fact. By placing a board, similar to that used taking the motion of the tendrils, against a leaf having a di eter of 12^{cm} and a petiole 22^{cm} long, a figure of twenty changes of direction was obtained within the space of tl hours. The movement was found to be much slower and figure much smaller than in the case of the tendrils. This, h ever, would appear to be the case from theoretical consid tions alone, when we compare the structural features of two and also take into account the great difference in diame The figure described by the nutating tip of the leaf was q regularly ellipsoidal, though the curve was retraced be the ellipse was fully completed, thus showing another p of similarity to the movement of the tendril. The figure tained was 8^{cm} long by 5·5^{cm} wide, and the movement the leaf appeared to be through the two ends and one ı of the ellipse. Whether this would hold true in all case not, could only be determined from a greater number of ob vations. The important fact is demonstrated, however, ' the leaves have a definite circumnutation, and that this depe upon the same causes which determine the movement of o organs in the same plant.

While experimenting with the tendrils, it was also dee advisable to determine the movements of the growing ext

* Assistant Professor of Botany, Wellesly College. The facts collected t were obtained during a course of Physiological Botany under my direction.

† This is in harmony with the observations of Sachs. Text-book, p. 870.

ity of the vine itself, since it was noticed that, usually directed upward, the tip described a movement which had a marked vertical and somewhat conspicuous lateral range. The method of securing the record was the same as for the tendrils, though owing to the constant advance of the terminal bud, the record paper was placed about six inches in advance, and the point of contact was then obtained by means of a rightangled triangle.

[To be continued.]

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *On a new Magnesium Carbonate.*—By the action of heat upon the double carbonate of magnesium and potassium, $MgCO_3 . HKCO_3 . (H_2O)_4$, ENGEL has produced a magnesium carbonate having exceptional properties. The heat should be raised gradually so as not to exceed 200°. The mass does not melt, but loses water and carbon dioxide; the crystals retain their form and are still transparent. But on adding water the potassium carbonate dissolves, leaving the magnesium carbonate anhydrous and nearly pure. This carbonate is distinguished chiefly by the facility with which it is transformed into hydrate. Mixed with water it evolves heat and in the course of two hours forms the hydrate containing five molecules of water, if the temperature is below 16° and three molecules if above 16°. It even attracts moisture from the air. Mixed with water to a magma, it solidifies so that the vessel may be inverted without its falling. It is much more soluble in water than the hydrated carbonates, the solution after a while depositing the hydrate in crystals, and the alkalinity of the liquid diminishing. The hydrates which it forms, however, lose easily their carbon dioxide under the influence of water and heat, like the ordinary hydrates.—*C. R.*, ci, 814, Oct., 1885.

G. F. B.

2. *On chlorine monoxide.* — GARZAROLLI-THURNLACKH and SCHACHERL have subjected chlorine monoxide to a more thorough investigation than appears to have been before attempted. The gas was prepared by passing a current of well dried chlorine over precipitated mercuric oxide, previously heated to 250° for several hours. The oxide was contained in a glass tube 1·2 meters long and 1·5 cm. in diameter, drawn out to a narrow delivery tube at one end and at the other closed by a paraffined rubber stopper, through which passed the tube for the entrance of the chlorine. The tube was placed in a tin trough surrounded with ice. With a moderately rapid current of chlorine, there was collected in the receiver (immersed in a freezing mixture of calcium chloride and ice) 15 to 20 c. c. liquid chlorine monoxide in three hours. The liquid was dark brown in color; its vapor yellowish-brown, its

solution in water a gold yellow. The gas was analyzed by composing a known volume by the electric spark and noting increase of volume as well the quantity of chlorine and of oxy set free. To lessen the force of the explosion, the gas was mi with dry carbon dioxide. If the gas be pure and have the fo ula Cl_2O, the chlorine set free should occupy the same volume the monoxide and the oxygen half this volume. In one exp ment 37·10 c. c. expanded to 55·33 c. c.; or 2 volumes to 2·9 The ratio of the chlorine to the oxygen was 37·12 to 18·54, or 0·999; and that of the oxygen to the expansion 18·54 : 18·23, 1 : 0·984; thus confirming the formula Cl_2O. Passed over calci chloride, chlorine was evolved and calcium hypochlorite produc The density of the monoxide was found to be in two determi tions 3·0258 at 22·30° and 3·0072 at 10·6°; or 43·69 and 43· referred to hydrogen, theory requiring 43·35. Its boiling po under a pressure of 737·9 mm. was found to be 5·0° to 5·1°.—*Lieb. Annalen*, ccxxx, 273, Oct., 1885. G. F. B

3. *On Lupanine, the alkaloid of Lupine.*—HAGEN has disc ered in the seeds of Lupinus angustifolius a new liquid alkal which he calls lupanine, which has the composition $C_{15}H_{25}N$ It is a monacid tertiary base.—*Liebig's Annalen*, ccxxx, 3 Oct., 1885. G. F. B

4. *On the Relation between Molecular Structure and Lig absorption.*—In 1882, HARTLEY explained the absorption ba of the spectra of various carbon compounds as due, the gen absorption bands to the fundamental vibrations of the molec the selective absorption bands to vibrations within the molec Since only those rays which are synchronous with the vibration a molecule are absorbed by it, the connection between these m cule-vibrations and the oscillation-frequencies of the absorb rays is obvious. Since, however, it is not possible to associ any of the absorption bands of the aromatic hydrocarbons w any particular carbon atoms within the molecule; and since vibrations of the molecule as a whole determine the rate of vibrations which take place within it, it follows that the evide thus given of the constitution of matter is inconsistent with present hypothesis of the individual existence of the atoms wit the molecule. In the present paper, the results of the exami tion of the ultra violet absorption-spectra, obtained by phot raphy, are given for certain aromatic hydrocarbons, tertiary b and their salts, their addition products, primary and second aromatic bases and the three isoxylenes. The molecular wei of the substance in milligrams was dissolved in 20 c. c. of absol alcohol or other suitable menstruum, so that a unit of volum the liquid always contained the same number of molecules. ' solutions so prepared were placed in cells varying in thick from 25^{mm} to 1^{mm}; and if in the latter, absorption bands w still visible the liquid was diluted five times and another serie photographs taken in cells from 5^{mm} in width downward. In case of the bases, the spark-rays passed first through their s

ion and then through the acid, placed behind it. The two liquids were then mixed, returned to the same cells and another photograph taken. The difference in the mode of vibration of the base, the acid and the salt is very striking, the amplitude of the vibrations within the molecule of the salt being much less than in that of the base. Using then the oscillation-frequencies (i. e., the reciprocals of the wave lengths), of the absorbed rays as abscissas and the proportional thicknesses of the weakest solution, in millimeters, as ordinates, a curve may be drawn indicating both the general and the selective absorption. From the results thus obtained the author draws the following deductions: (1.) When the condensation of the carbon and nitrogen in the molecule of a benzenoid compound or tertiary base is modified by the addition thereto of an atom of hydrogen to each atom of carbon and nitrogen, the power of selective absorption is destroyed; (2.) When the condensation of the carbon atoms in quinoline is modified by the combination therewith of four atoms of hydrogen, the intensity of the selective absorption is reduced, but is not destroyed; (3.) Molecules of compounds, that is to say, composed of dissimilar atoms, vibrate as wholes or units, and the fundamental vibrations give rise to secondary vibrations which stand in no visible relation to the chemical constituents of the molecule whether these be atoms or smaller molecules. Hence it appears that a molecule is a distinct and individual particle which cannot be represented by our usual chemical formulas, since these only symbolize certain chemical reactions and fail to express any relation between physical and chemical properties.—*J. Chem. Soc.*, xlvii, 685, Oct., 1885. G. F. B.

5. *On the Variation of Refractive Indices with Temperature.* —DUFET has continued his researches on the change produced by temperature in the refractive index of solid and liquid bodies, and has now published the results obtained with water, fluorite, beryl, carbon-disulphide, monobrom-naphthalene, turpentine and alcohol. The mean index of water was first determined by the usual method, a large prism of 90° being used and a Gambey theodolite reading to 5″. The value obtained, for the line D and at a temperature of 20°, was 1·33292. The index was then determined for thirteen other lines of the spectrum at the same temperature. The variation of the index was determined for the line D only. Two methods were employed, in each of which two series of experiments were made. In the first or prism method, hollow prisms of 90° and of 45° were used in the two series. The former was adjusted to minimum deviation for parallel rays and the deviation noted. The cold water contained in it being replaced by hot, successive readings of the theodolite and thermometer gave the deviation and the corresponding temperature. The 45° prism received the incident light normally on one of its faces; otherwise it was similarly used. In the second method, Talbot's bands were observed, using a transparent plate with parallel faces immersed in water. From the displacement of

these bands as the temperature changes, the derivative (difference of the indices of the plate and the liquid with r to the temperature may be deduced. In the first series of e ments a quartz plate, in the second a crown glass plate, was The results of the four sets of measurements are given in a the temperatures varying from 9° to 50°. With these are co the values previously observed by others. These results of vation agree well with those given by a curve of the third d calculated by the method of Cauchy, the equation of wh

$$\frac{dn}{dt} = -10^{-7}(125{\cdot}46 + 41{\cdot}285t - 0{\cdot}01304t^2 - 0{\cdot}00460t^3).$$

grating this expression, we have $n = n_0 - 10^{-7}(125{\cdot}5t + 2($ $-0{\cdot}00435t^3 - 0{\cdot}00115t^4)$ by which the index may be calc for any temperature. This equation gives 1·33397 as the of the refractive index at 0° and 1·32896 at 50°. Plates of fl and beryl immersed in water, at temperatures varying fro to 37°, gave for the mean value of the derivative — 0·00(whence $n = n_0 - 0{\cdot}0000134t$, in the case of fluorite; and i case of beryl, $\frac{dO}{dt} = 10^{-7}(189{\cdot}4 - 10{\cdot}34t + 0{\cdot}2735t^2)$ for the nary and $\frac{dE}{dt} = 10^{-7}(180{\cdot}3 - 10{\cdot}314t + 0{\cdot}2735t^2)$ for the ordinary index. The rate of variation of the indices of ca disulphide, monobrom-naphthalene, turpentine and alcohol determined by means of Talbot's bands. The first ga $= -0{\cdot}0006320 - 0{\cdot}00000870t$; the second $\frac{dn}{dt} = -0{\cdot}000$ (group 1), $-0{\cdot}00046404$ (group 2); the third $\frac{dn}{dt} = -0{\cdot}000$ and the fourth $\frac{dn}{dt} = -0{\cdot}0004179$. In the case of the last it will be observed that the variation of the index is propor to the temperature.—*J. Phys.*, II, iv, 389, Sept., 1885. G. F

6. *On a Spectroscopic Optometer.*—The difficulty of dete ing rigorously, by means of the existing optometers, the dis of distinct vision in abnormal eyes, has led ZENGER to the struction of a spectroscopic optometer. Since with the ord instruments, the recognition with any precision, of the exact tion of the tube at which the slit ceases to appear double, is nigh impossible, the author first sought to determine the acc of the observation by using a lens made of Iceland spar, cu pendicularly to the optic axis. With this lens the two pos were observed in which the slit appeared single; correspo to the ordinary and extraordinary foci respectively. Fro data thus obtained calculation gives two values of the dista distinct vision; by the amount of disagreement of whicl error of the method can be ascertained. In this way it was s that errors of one or two centimeters even, may be comi in measuring the eyes of aged persons. While using this a

s, Zenger was struck with the great increase in accuracy obined by illuminating the slit with monochromatic light; and is led to the employment of a direct-vision pocket spectroscope, e collimating lens of which was removed and the slit replaced y a silvered cylindrical mirror, 16mm. in diameter. The whole as mounted upon a board, the mirror sliding in a groove so that s distance from the spectroscope could be readily adjusted. he edge of this groove was divided into millimeters. Standing ith one's back to a window and looking through the spectroscope ; the narrow line of light reflected from the mirror, a brilliant pectrum is seen, the Fraunhofer lines appearing at the eye end f the instrument. But in order that the different lines should be ı focus, it is necessary to adjust for each by moving the mirror) or from the prism, the distance of a single millimeter causing iese lines to appear or disappear. Hence the distance of distinct ision, for normal eyes and for a given line may be readily deterined; these distances showing a difference of one to one and a half entimeters in passing from the lines D or E to the lines F or G. 'or abnormal eyes, the finer lines may be used and the degree of ensitiveness for different colors determined with great sharpness, greeing to within a millimeter. In practice the method is found atisfactory.—*C. R.*, ci, 1003, Nov. 1885. G. F. B.

7. *On Magnetization by the Electric Discharge.*—Many years go Savary showed that when a steel needle was magnetized by ieans of an electric discharge in its vicinity, the amount of the ffect produced was variable and the direction not uniform. LAVERIE has confirmed these results and has given a satisfactory explanation of them. His experiments were made with a attery of 12 jars each of the capacity of 0·01 microfarad, harged to a potential determined by the length of spark as ieasured with a micrometer. The needles, previously hardened, vere placed in a magnetizing spiral 300 mm. long and 13 mm. in iameter, made of a copper wire 0·5 mm. in diameter, the turns eing $\frac{10}{9}$ of a millimeter apart. In this spiral, the magnetic field roduced by a unit current was practically uniform for a needle 5 mm. long, varying only from $9\pi\times1·998$ in the center, to $\pi\times1·9975$ at a distance of 5 centimeters in either direction. 'he author finds that such a needle 0·5 mm. diameter, magnetized ı this spiral by an electric discharge whose striking distance is 0 mm., develops on immersion in hydrochloric acid, alternate olarities as the layers are successively dissolved. On examining he needle at intervals of ten minutes its magnetic moment, in rbitrary units, was found to vary as follows: +20·5, +14·5, +5, −5, −11, −15, −18·5, −18, −13·5, −16, −13, −9, −6, -3·5, −2, +5, +7, +8, +10·5, +12, +11·5, +11, +8·5, +6·5, +6, +3, +2, +1, −0·5, −0·5, +0.5. The plus sign here indicates polarity according to Ampère's law. Now, Feddersen as shown that the discharge of a condenser, through a circuit of ow resistance, consists of oscillations between the armatures, with a gradually decreasing intensity; and that as the external

resistance is progressively increased by the insertion of a column of liquid, a point is reached where the discharge becomes continuous. Interposing in the circuit above described a column of copper sulphate solution 112 mm. long and 3 mm. in diameter, and magnetizing a needle by a discharge of 8 mm. tension, which sufficed to magnetize it to its center, the author finds that now the direction of polarity conforms to the law of Ampère, and is the same at different depths. Stronger discharges, under tensions of 10 or 12 mm., give the same magnetic moment. Weaker ones magnetize the needle to a less depth. Since now the depth of the magnetization is a function of the quantity of electricity discharged, it is evident that two discharges in opposite directions, of which the second is the stronger, should leave the needle in the same condition as if it alone had acted. But if the second is so feeble as not to magnetize the needle to the center, it will produce a shell of polarity opposite to that induced by the first discharge. So that when the needle is acted on by hydrochloric acid, the magnetism produced by the second discharge would be found in the superficial layers, while that of the first would be observed at a greater depth. This result experiment confirms. A needle magnetized by an oscillatory discharge alternating in direction and decreasing in intensity, the first of which magnetizes it to the axis, will be found to develop successively on immersion in hydrochloric acid, the different polarities due to the different discharges. The resulting polarity of a needle magnetized in this way is of course uncertain, depending upon the direction and intensity of the discharge, and especially of the latter portions which magnetize the superficial layers.—*C. R.*, ci, 947, Nov., 1885. G. F. B.

8. *Astronomical Papers prepared for the use of the American Ephemeris and Nautical Almanac.* Vol. II, parts 3 and 4. *Velocity of Light in Air and Refracting Media.* Washington, 1885.—Professor NEWCOMB obtains as the final result of his experiments at Washington 299,860±30 kilometers per second for the velocity of light *in vacuo.* Professor MICHELSON's entirely independent experiments at Cleveland give substantially the same result (299,853±60). His former experiments at the Naval Academy, after correction of two small errors which he now reports, give 299,910±50. All these experiments were made with the revolving mirror, but the arrangements of the two experimenters were in other respects radically different. The first of these values of the velocity of light with Nyrén's value of the constant of aberration (20″·492) gives 149·60 for the distance of the sun in millions of kilometers. On account of the recent announcement by Messrs. Young and Forbes of a difference of about two per cent in the velocities of red and blue light, especial attention was paid to this point by both experimenters, without finding the least indication of any difference. In Professor Newcomb's experiments, a difference of only one thousandth in these velocities would have produced a well-marked iridescence on the edges of the return imag

f the slit formed by reflection from the revolving mirror. No race of such iridescence could ever be seen. Professor Michelson made an experiment, in which a red glass covered one-half the slit. The two halves of the image—the upper white, the lower red—were exactly in line.

Since Maxwell's electromagnetic theory of light makes the velocity of light in air equal to the ratio of the electromagnetic and electrostatic units of electricity, it will be interesting to compare some recent determinations of this ratio. These we give in the following table. Since the determinations are affected by any error in the standard of resistance, we have corrected the results, first, on the supposition that the B.A. ohm = ·987 true ohms (Lord Rayleigh's result), and secondly, on the supposition that the B.A. ohm = ·989 true ohms, which is essentially assuming that the legal ohm represents the true value.

Ratio of Electromagnetic and Electrostatic units of Electricity in millions of meters and seconds.

	Date.	As published.	B.A. ohm = ·987.	B.A. ohm = ·989.
Ayrton & Perry,*	1878	298·0	296·1	296·4
Hockin,†	1879	298 8	296·9	297·2
Shida,‡	1880	299·5	295·6	296·2
Exner,§	1882	301·1 (?)	291·7 (?)	292·3 (?)
J. J. Thomson,‖	1883	296·3	296·3	296 9
Klemencic,¶	1884	301·88 (?)	301·88 (?)	302·48 (?)

These numbers are to be compared with the velocity of light in air, in millions of meters per second, for which Professor Newcomb gives 299·778. Of the electrical determinations, that of J. J. Thomson appears by far the most worthy of confidence. That of Klemencic—the only one as great as the velocity of light—was obtained by the use of a condenser with glass,—a method which would presumably give too great a ratio. Exner's value is obtained from the mean of three determinations, one of which differed from the others by about three per cent. If we reject this discordant determination, the mean of the other two would give when corrected for resistance 294·4 and 295·0. If we set aside the determinations of Exner and Klemencic, the remaining four, which represent three different methods, are very accordant, the mean being nearly identical with the result of J. J. Thomson, and about one per cent less than the velocity of light.

Professor Michelson's experiments on the velocity of light in carbon disulphide afford an interesting illustration of the difference between the velocity of waves and the velocity of groups of waves—a subject which is treated at length in an appendix to the second volume of Lord Rayleigh's *Theory of Sound.* If we write V for the velocity of waves, U for that of a group of waves, L for the wave-length, and T for the period of vibration,

$$V = \frac{L}{T}, \qquad U = \frac{d\,(T^{-1})}{d(L^{-1})}.$$

* Phil. Mag., 5, vii, p. 277.
† Report Brit. Assoc., 1879, p. 285.
‡ Phil. Mag., 5, x, p. 431.
§ Sitzungsberichte Wien. Acad., lxxxvi, p. 106.
‖ Phil. Trans., clxxiv, p. 707.
¶ Sitzungsberichte Wien. Acad., lxxxix, p. 298.

For purposes of numerical calculation, it will be convenient to transform these formulæ by the use of λ for the wave-length *in vacuo*, n for the index of refraction of the medium considered, and k for the velocity of light *in vacuo*, which we shall regard as constant, in accordance with general usage. By substitution of these letters we easily obtain

$$\frac{k}{V}=n, \qquad \frac{k}{U}=\frac{d(n\lambda^{-1})}{d(\lambda^{-1})}.$$

The data for the calculation of these quantities for carbon disulphide are given by Verdet (Annales de Chimie et de Physique, 3, lxix, p. 470). They give

for the line D, $k/V= 1{,}624$, $k/U= 1{,}722$,
for the line E, $k/V= 1{,}637$, $k/U= 1{,}767$.

The quotient of the velocity *in vacuo* divided by the velocity in carbon disulphide, according to Professor Michelson's experiments with the light of an arc lamp, is 1·76±·02, which agrees very well with k/U. Another theory, which would make the velocity observed in such experiments V^2/U (*Nature*, xxv, p. 52), receives no countenance from these experiments. The value of kU/V^2 would be about 1·53. Some may think that the experiments on water point in a different direction. Taking our data from Beer's *Einleitung in die höhere Optik*, 1853, p. 411, we get

for D, $k/V= 1{,}334$, $k/U= 1{,}352$, $kU/V^2= 1{,}316$,
for E, $k/V= 1{,}336$, $k/U= 1{,}359$, $kU/V^2= 1{,}313$.

The number obtained by experiment was 1,330, which agrees better with k/V, or even with kU/V^2, than with k/U, but the differences are here too small to have much significance.

J. W. G.

9. *Theoretische Optik, gegründet auf das Bessel-Sellmeier'sche Princip, zugleich mit den experimentellen Belegen.* Von Dr. E. KETTELER, Professor an der Universität in Bonn. 8°, pp. 652. Braunschweig, 1885. Viewig und Sohn.—The principle of Sellmeier, here referred to, relates to vibrations of ponderable particles excited by the etherial vibrations of light, and to the reaction of the former upon the latter. The name of Bessel is added on account of his previous solution of a somewhat analogous problem relating to the pendulum. The object of this work is "to treat theoretical optics in a complete and uniform manner on the new foundation of the simultaneous vibration of etherial and ponderable particles, and to substitute a consistent and systematic new structure for the present conglomerate of more or less disconnected principles." Such a work demands a critical examination, which should not be undertaken from any narrow point of view. Any faults of detail will be readily forgiven, if the author shall give the theory of optics the ποῦ στῶ which it has sought so long in vain. We may add that if this effort shall not be judged successful by the scientific world, the author will at least have the satisfaction of being associated in his failure with many of the most distinguished names in mathematical physics.

We have sought to test the proposed theory with respect to ıat law of optics which seems most conspicuous in its definite ıathematical form, and in the rigor of the experimental verifica-ons to which it has been subjected, as well as in the magnificent evelopments to which it has given rise: the law of double refrac-on due to Huyghens and Fresnel, and geometrically illustrated y the wave surface of the latter. We cannot find that the law f Fresnel is proved at all in this treatise. We find on the con-rary, that a law is deduced which is different from Fresnel's, and ıconsistent with it. We do not refer to anything relating to the irection of vibration of the rays in a crystal, which is a point ot touched by the experimental verifications to which we have lluded. We shall confine our comparison to those equations rom which the direction of vibration has been eliminated, and which therefore represent relations subject to experimental con-rol. For this purpose equation (13) on page 299 is suitable. It eads

$$\frac{u^2}{n_x^2-n^2}+\frac{v^2}{n_y^2-n^2}+\frac{w^2}{n_z^2-n^2}=0,$$

$_x$, n_y, n_z being the principal indices of refraction. This the au-hor calls the equation of the wave-surface or surface of ray-elocities. It has the form of the equation of Fresnel's wave-sur-ace, expressed in terms of the direction-cosines and reciprocal of he radius vector, and if u, v, w are the direction-cosines of the *ay*, and n the velocity of light in vacuo divided by the so-called *ay-velocity* in the crystal, the equation will express Fresnel's law. But it is impossible to give these meanings to u, v, w and n. They are introduced into the discussion in the expression for the ibrations (p. 295), viz:

$$\rho=\mathfrak{A}\cos 2\pi\left(\frac{t}{T}-\frac{n(ux+vy+wz)}{\lambda}\right).$$

The form of this equation shows that u, v, w are proportional o the direction-cosines of the *wave-normal*, and as the relation $u^2+v^2+w^2=1$ is afterwards used, they must be the direction-cosines of the wave-normal. *They cannot possibly denote the direc-ion-cosines of the ray*, except in the particular case in which the ray and wave-normal coincide. Again, from the form of this equation, λ/n must be the wave-length in the crystal, and if λ here as elsewhere in the book (see p. 25) denotes the wave-length *in vacuo* of light of the period considered, which we doubt not is the intention of the author, n must be the wave-length *in vacuo* divided by the wave-length in the crystal, i. e., the velocity of light *in vacuo* divided by the *wave-velocity* in the crystal. With these definitions of u, v, w, and n, equation (13) expresses a law which is different from Fresnel's. Applied to the simple case of a uniaxial crystal, it makes the relation between the wave-veloci-ty of the extraordinary ray and the angle of the wave-normal

with the principal axis the same as that of the radius vector and the angle in an ellipse. The law of Huyghens and Fresnel makes the *reciprocal* of the wave-velocity stand in this relation.

The law which our author has deduced has come up again and again in the history of theoretical optics. Professor Stokes (Report of the British Assoc., 1862, Part I, p. 269) and Lord Rayleigh (Phil. Mag., IV, xli, p. 525) have both raised the question, whether Huyghens and Fresnel might not have been wrong, and it might not be the wave-velocity and not its reciprocal which is represented by the radius vector in an ellipse. The difference is not very great, for if we lay off on the radii vectores of an ellipse distances inversely proportional to their lengths, the resultant figure will have an oval form approaching that of an ellipse when the eccentricity of the original ellipse is small. Rankine appears to have thought that the difference might be neglected (see Phil. Mag., IV, i, pp. 444, 445), at least he claims that his theory leads to Fresnel's law, while really it would give the same law which our author has found. (Concerning Rankine's "splendid failure," and the whole history of the subject, see Sir Wm. Thomson's *Lectures on Molecular Dynamics at the Johns Hopkins University*, Chap. xx.) Professor Stokes undertook experiments to decide the question. His result, corroborated by Glazebrook, (P. R. S., xx, p. 443; Phil. Trans., clxxi, p. 421,) was that Huyghens and Fresnel were right and that the other law was wrong.

To return to our author, we have no doubt from the context that he regards u, v, w, and n as relating to the ray and not to the wave-normal. We suppose that that is the meaning of his remark that the expression for the vibrations (quoted above) is to be referred to the direction of the ray. It seems rather hard not to allow a writer the privilege of defining his own terms. Yet the reader will admit that when the vibrations have been expressed in the above form an inexorable necessity fixes the significance of the direction determined by u, v, w, and leaves nothing in that respect to the choice of the author.

The historical sketches of the development of ideas in the theory of optics, enriched by very numerous references, will be useful to the student. An exception, however, must be made with respect to the statements concerning the electro-magnetic theory of light. We are told (p. 450) that the English theory founded by Maxwell and represented by Glazebrook and Fitzgerald, makes the plane of polarization coincide with the plane of vibration, while Lorentz, on the basis of Helmholtz's equations comes to the conclusion that these planes are at right angles. Since all these writers make the electrical displacement perpendicular to the plane of polarization, we can only attribute this statement to some confusion between the electrical displacement and the magnetic force or 'displacement' at right angles to it. We are also told that Glazebrook's 'surface-conditions' which determine the intensity of reflected and refracted light are different from those of Lorentz,—a singular

view of the fact that Mr. Glazebrook (Proc. Cambr. Phil. p. 166) expressly states that his results are the same as Lorentz, Fitzgerald, and J. J. Thomson. We have spent uitless labor in trying to discover where and how the ex-s were obtained which are attributed to Glazebrook, but ı the notation has been altered. They ought to come azebrook's equations (24)–(27) (*loc. cit.*), but these appear l with Lorentz's equations (58)–(61) (Zeitschrift f. Math. ., xxii, p. 27). They might be obtained by interchanging ressions for vibrations in the plane of incidence and at ıgles to it, with two changes of sign.

eader must be especially cautioned concerning the state-nd implications of what has not been done in the electro-c theory. These are such as to suggest the question · the author has taken the trouble to read the titles of the which have been published. We refer especially to what on pages 248, 249 concerning absorption, dispersion, and ;netic rotation of the plane of polarization.

e Experimental Part, with which the treatise closes, we comparison of formulæ with the results of experiments ıuthor and others. The author has been particularly suc-in the formula for dispersion. In the case of quartz (p. e formula (with four constants) represents the results of ıent in a manner entirely satisfactory through the entire f wave-length from 2·14 to 0·214. Those who may not ith the author's theoretical views will nevertheless be glad he results of experiment brought together, and, so far as represented by formulæ. J. W. G.

'he magnetic and electrical properties of the iron carburets; ·ARUS and V. STROUHAL. Bull. 14, U. S. Geological Sur-ashington, 1885.—The authors give in complete form the of about five years of research on the properties of the ·burets. Proposing to investigate the relation between y of magnetism, hardness, figure and carburation of steel, d during the course of the investigation that the end in ust remain unattainable as long as the physics of the ope-ıf tempering have not been rigidly discussed. The results ɜ auxiliary experiments are contained in the first three s of the book. The general deduction is this, that if one same steel rod pass from an initial hard to a final soft state, ermediate degree of hardness can be defined with extreme y, by using as a means of discrimination either the ther-tric power or the electrical resistance of the rod. Chap-ıerefore, treats of the relation between temperature and ıce in case of any given carburet and leads to chapter II, h the electrical behavior of tempered steel is minutely an-This chapter is fundamental. Such facts as essentially the argument underlying the whole of the subsequent ıre therefore emphasized by many experimental data. The ng effect of any temperature acting on glass-hard steel is

found to increase, gradually at a rate diminishing continuously through infinite time—diminishing very slowly in case of low temperatures (<100°), very rapidly at first and then again slowly in case of high temperature (> 200°); so that the highest and hardest of the inferior states of hardness possible at any temperature is approached asymptotically. The observed law that thermo-electric power and specific resistance are linear functions of each other, suggests the introduction of the new variable thermo-electric hardness, which is used as the measure of hardness throughout the work. In chapter III, finally, the attempt is made to throw new light on the laws set forth in chapter II, by following them into their ulterior consequences. With the aid of certain allied electrical properties observed in alloys of silver and in malleable cast iron, the nature of the phenomenon of hardness as presented by steel is discussed from every physical and chemical point of view, within the scope of the memoir.

With these results in hand the authors commence the study of the subject proper of the research, the magnetic behavior of tempered steel. An introductory chapter, IV, determines the value and relations of the thermo-electric effect of magnetization. Chapter V then exhibits with some detail, the effect of hardness on the maximum of magnetization which thin cylindrical steel rods of different dimensions permanently retain. The method for the accurate definition of hardness and the scheme of operations for tempering developed in chapter II, are here rigidly adhered to; the magnetic results reached are therefore sharp and consistent. Chapter VI investigates the bearing of temper on the condition of magnetic stability of steel. Whenever great retentiveness, both as regards the hurtful effects of temperature and time and shocks is to be conveniently attained with the least sacrifice of magnetization, magnets should be treated thus:

1. Having tempered the steel rod uniformly, expose it for a long time (20 to 50 hours) to the annealing effect of steam. The operation may be interrupted as often as desirable. The magnet will then exhibit the maximum of permanent hardness for 100°.

2. Magnetize the rod and again expose it for some time (5 to 10 hours) to the annealing effect of steam. The operation may be often interrupted. The magnet will then exhibit both the maximum of permanent magnetization as well as the maximum of permanent hardness for 100°. It will show exceptional retentiveness at ordinary temperature.

Finally in chapter VII, the authors endeavour to generalize on the foregoing results [illegible] restate the principal facts with greater [illegible] than was possible in [illegible] for the physical [illegible] that the difference [illegible] values of thermo-electric [illegible] passes through a [illegible] mechanical properties [illegible] steel.

. *Joseph Henry and the Magnetic Telegraph:* An address deliv-
ı at Princeton College, June 16, 1885, by EDWARD N. DICKER-
, LL.D. 66 pp. 8vo. New York, 1885. (C. Scribner's Sons.)—
ıst tribute to the late Professor Henry, reviewing his scientific
ırs and discoveries, and giving them their right place in the
gress of physical science. The historian of the world's
nce should consult it for the review of the facts which it
ents.

2. "*The Force Function in Crystals;*" by ALFRED EINHORN,
D. Communicated to the Royal Society, Nov. 27, 1884.
oceedings of the Royal Society, vol. xxxviii, No. 235.)—The
; part of the paper, which appears at present, restricts itself to
consideration of the Tesseral, Tetragonal and Rhombic sys-
s. By means of a well founded assumption in regard to the
ss distribution in crystals of the above systems, the equilib-
n conditions are deduced which further involve that the
ndary of the configuration must either be plane or spherical.
lso appears that the statical conditions of the agency which
ses crystallization are the same as those so well investigated
gravitation and electricity.

'he paper is divided into three chapters. The first chapter
ts of the "Foundation of the Assumption." The assumption
hat the stress upon any particle can only be transmitted in
directions-lines, respectively at right angles in pairs to the
e crystallographic axes—it is a consequence of the internal
cture which is shown to be analogous to that of an ordinary
non-ball pile by means of the cleavage properties, the external
n and inertia relations of crystals.

'he second chapter, "Derivation of the Force Function," ap-
s the three general differential equilibrium equations of an
tic solid subject to internal forces to the stated stress distri-
ion. In order to effect this it was necessary to deduce some
uliarities of the force function in a system of uniform density
quilibrium and subject to internal forces when referred to the
e principal axes of inertia through the mass center. The
racter of the attracting agency here becomes evident.

'he third heading is "Determination of the Boundary." Under
heading the nature of the boundary is determined and is
wn to be either plane or spherical. And by the application of
een's theorem it also becomes clear that inasmuch as the stati-
conditions of the crystallizing agent are now understood; the
ce functions derived in the preceding chapter can be inde-
ndently deduced without aid of the assumption from any one
the primitive forms of the systems under consideration. O. N. R.

II. GEOLOGY AND MINERALOGY.

1. *The Missouri Coteau and its Moraines.*—Professor J. E.
ODD gives an account, in the Proc. Amer. Assoc., xxxiii, 381, 1884,
f the features and drift deposits of the Coteau and illustrates

the subject with a map. The eastern margin is near the con
line of 1500 feet. He mentions as one singular fact bearin
the Quaternary history: that the Missouri River flows for
to 600 miles from north to south along the western side o
region of drift, while only 40 to 70 miles east, with nothin
clay, sand and gravel between, there is parallel to it, the
James River, 200 to 250 feet lower in level, and occupying
bottom of a valley 25 to 60 miles wide, while that of the Mis
above Yankton is comparatively insignificant. He conclude
the deposition of the drift determined this westward confine
of the greater river; for evidence is afforded that the Mis
has recently run 300 to 400 feet above its present level.

The Coteau is made mostly of clays of the "St. Pierre"
taceous) group—nearly horizontally bedded, capped with
"Fox Hills" sandstone to the northward and the "Lone R
sandstone to the southward. Its western side is intersecte
channels of erosion in "bad-land" style; its eastern once
such channels, but they are now occupied largely with
brought from the northeastward, making a region of mo
hills and basins. There are two prominent lines of moraines,
sisting of loops convex to the westward, determined in o
probably by the configuration of the surface. The outer or
ern is most pronounced; it is crossed by the Pacific rai
diagonally a little west of Sterling about 20 miles east of
marck, and has indications of four great lobes in the ice.
limit of the drift is marked on the map as following a line
30 miles west of the Missouri. The inner or eastern mo
crosses the railroad a little west of Crystal Springs.

2. *Geological Survey of Pennsylvania*, J. P. Lesley,
Geologist.—The publication of the Grand Atlas of the S
of Pennsylvania has been carried forward by the recent iss
three more parts in the same thorough and beautiful style
acterizing the two parts previously published. These in
Part II of Division II, On the Anthracite Coal Fields, by C
A. Ashburner, contain 22 sheets (the size, as in the others, 2
inches) relating to portions of the Northern and Eastern M
Anthracite Fields in Luzerne County; Part I of Divisi
illustrating the geology and topography of Central and S
eastern Pennsylvania, and including 35 sheets, 29 of them
ing to the Paleozoic formations, five containing a map and
logical cross-sections along the east bank of the Susque
River, Lancaster Co., and one containing cross-sections o
Philadelphia belt of Azoic Rocks; and Part I of Divisio
illustrating the topography, by contour lines, on 43 sheets, o
South Mountain and Great Valley, 30 of the sheets pertaini
the Durham and Reading Hills and bordering valleys in N
ampton, Lehigh, Bucks and Berks Counties, and 13 to the
Mountains in Adams, Franklin, Cumberland and York Cou
The maps surpass in style and size those of other State pu
tions of the country.

3. *Atlas von China: Orographische und Geologische Karten;* von FERDINAND FREIHERR VON RICHTHOFEN; zu des Verfasser's Werk, *China.* Erste Abtheilung; *das Nordliche China.*—This large atlas to the second volume of Baron Richthofen's great work on China contains a duplicate series of colored charts representing, in different colors and on a scale of 1 : 750,000, the orographic features and geological structure of Northern China. Twelve regions, each about 130 by 170 geographical miles in area, are thus illustrated—five of them about the Yellow Sea; one, that of Pekin, just west; and six to the west, south, and southwest of Pekin. The coloring of the charts is in the best style of Vienna artists; 15 to 20 shades are used on the several charts. By the different colors are exhibited the areas of the immense alluvial plains of the Hoang-ho about the Yellow Sea; of the marine lœss; of the lœss of the interior regions; of the gneiss; of other metamorphic rocks; eruptive granite; Lower and Upper Cambrian (Sinian); Silurian with Devonian; Carboniferous limestone; Productive Carboniferous; Trias; Jurassic; porphyry; trachyte and basic eruptives. Cambrian schists have a wide distribution, covering over a thousand of square miles (geographical), and near Pekin they are strongly metamorphic. Silurian and Devonian beds, and also Carboniferous and Permian occur to the southwest of Pekin in Tsing-ling-shan and the district next east. The Carboniferous beds, which are the highest formation over much of the interior, also exist in the hilly parts of the districts near the Yellow Sea. The work is a large contribution to the Systematic Geology of Northern China.

4. *Swedish Geological Survey.* — The Geological maps of the Swedish Geological Survey now issued number 96, and extend over about half the surface of the country. They are models of beautiful coloring, and careful details. The larger part are on a scale of 1 : 50,000; a few on that of 1 : 200,000. The price charged for the sheets is 1·50 kr. each. Besides these there are four general charts (one of these glacial) and three special. The publications of the survey thus far issued include also 77 memoirs in 8vo, and 4to, by the geologists of the survey, A. Erdmann, E. Erdmann, A. Börtzell, A. E. Törnebohm, O. Gumælius, D. Hummel, J. G. O. Linnarsson, H. Santesson, O. Torell, A. G. Nathorst, E. Svedmark, A. Blomberg, S. L. Torquist, S. A. Tulleberg, F. Svenonius, B. Lundgren, F. Eichstädt, G. DeGeer, M. Stolpe, J. C. Moberg.

5. *The earliest* (*Devonian*) *winged Insects of America.* (8 pp., with one plate. Cambridge, Mass.)—Mr. S. H. SCUDDER, in this paper, reviews the facts with regard to the five earliest of American winged Insects, and concludes that the genus *Gerephemera* belongs to the group of Protophasmidæ, one, Platephemera, to the Ephemeridæ, and three, Homothetus, Lithentomum, and Xenoneura, to as many distinct families of ancient Neuroptera. He repeats a former conclusion that in the historic developement of the broader group of insects, so far as we now are acquainted

with them, no important changes have transpired since Paleozoic time ; while at the same time, our perplexity regarding the proper relation of Paleozoic insects to modern types is often very great.

6. *Footprints on the Triassic Sandstone (Jura-Trias) of New Jersey.*—Mr. JOHN EYERMAN reports to the Editors (Sept. 10), by the gift of a fine photograph, the discovery of foot-prints, related to *Anomœpus major* of Hitchcock in size and characters—from near Milford, Hunterdon County, New Jersey. On the larger slab the fore-foot is 4-toed and 6 inches long and broad; the hind-foot is 3-toed and 12 inches long. On a smaller slab on which there is one track only, that of the fore-foot, there are five toes, and the length is 7½ inches. The specimens are now in the Geological Museum of Lafayette College.

7. *Cervus Americanus* Harlan, *from shell-marl beneath a bog in Warren Co., New Jersey.*—This species was founded on a few bones from Big-Bone Lick, Kentucky (Proc. Philad. Amer. Phil. Soc., 1818, 376). The Fourth Annual Report (June 1885) of the E. M. Museum of Geology and Archæology of Princeton, contains a plate representing a fine skeleton from the above-mentioned locality now in the museum. Professor Scott institutes for it the new genus Cervalces. The skeleton fails only in five caudal vertebræ, 1 scapula, 1 humerus, 1 calcaneum, 2 ribs, 3 carpals, 1 phalanx, and some of the sesamoids.

8. *Pteropod of the St. John Group.* (From a letter by Mr. G. F. MATTHEW, dated St. John, New Brunswick, Dec. 8.)—I have received a letter from Mr. Ottomar Novák, of Prague, in answer to one giving him a description and figures of the new genus of Hyolithoid Pteropod of the St. John group (Cambrian), described in this Journal, October, 1885, page 205, under the name of Diplotheca.

He informs me that Phragmotheca of Barrande, to which I had compared it, may be described as "a Hyolithes having a triangular section, and on each side a great dilation of the testa;" and that Barrande's figure "represents only the apical end of the whole sheath, the opposite end bearing the opening being unknown." This being the case, the known portion of Phragmotheca corresponds to the septate portion of the sheath of Diplotheca, and not to the whole sheath (including the lateral phragmated portion). It follows, as Mr. Novák has remarked, that there is no special relation between the two genera.

I may add that the upper dotted line of the fig. 3*b*, page 294, giving the section of Phragmotheca, is erroneous as regards the dotted line connecting the wings, there being no enclosed space at the side of the sheath. The lateral partition and diaphragms of Diplotheca are therefore features which distinguish it from other Hyolithoid shells.

9. *Annuaire Géologique Universel et Guide du Géologique*, by Dr. DAGINCOURT, Sec. Soc. Geol. de France. 438 pp. 12mo. Paris, 1885.—This volume contains brief geological sketches of the different countries of the world, and notices or mention of

ent geological publications; and, following, the names
resses of the geologists and mineralogists of the world.
ery convenient office companion for all workers in geology
eralogy. The American part is evidently made up from
s excellent "International Scientist's Directory," but with
s often of initials and an occasional oversight, that may
corrected in another year's issue of the work.

hlamydoselachus anguineus Garm., *a living species of nt Shark;* by S. GARMAN. Bull. Mus. Comp. Geol. lge, vol. xii, No. 1, July, 1885.—This fine memoir of geological as well as zoological interest is illustrated by s.

uth Carolina: Resources and population, institutions and es. Published by the State Board of Agriculture; A. P. Commissioner. Charleston, 1885. (8vo, pp. viii + unnumbered, 1 plate, 2 folding tables, map 27×34 —The State is divided into seven "agricultural and physions," viz: I, the Coast region, II, the Lower Pine belt or h region, III, the Upper Pine belt or Central Colton belt, Red Hills, V, the Sand Hills, VI, the Piedmont region, , the Alpine region; and the topography, geology, and ıral capabilities of each are briefly described. The geotter is mainly a compilation of well-known facts and prinom the publication of Tuomey, Bieber, Ruffin and others, e observations and applications are apparently original. t only is Kerr's generalization of the southward deflection North Carolina rivers extended to South Carolina, but it that the coastal islands are triangular, with the apex d southwest, often terminating in marshes, while the ınd drier base faces northeast," and that in the coastal e "ship channels are always found to the south of the " The map (10 miles: 1 inch) exhibits, by means of colors ck boundary lines, the fresh water swamps and salt the two pine belts, the Red Hill and Sand Hill regions, hern limits of Pliocene, Ashley and Cooper (Eocene), Eocene), and Cretaceous marls, the Buhrstone (Eocene), n, and the different lithologic phases of the "Huronian," tian," and "Igneous" rocks. It is embellished by a crude rom Charleston to Ridgeway. The volume contains lists rate animals by F. W. True, of the invertebrate fauna Howard, and of the more common native and naturalized y H. W. Ravenel, together with abstracts of meteorobservations, etc. W. J. MC G.

obellite from Colorado.—Messrs. H. F. and H. A. KELLAR ently given a description of a variety of Kobellite from s of the Lilian Mining Co., in Printerboy Hill, near Leadolorado. It occurs in nodules of various sizes up to sevt in diameter; they are usually more or less oxidized. sh mineral has a fine-grained crystalline structure, a steellor and dark gray to black streak. Three analyses were ith the following results:

	S	Bi	Pb	Ag	Cu	Gangue.
1.	15·21	32·62	43·94	5·78	*tr.*	0·15=97·70
2.	15·27	33·31	44·28	5·49	0·03	0·14=98·52
3.	15·19	33·89	44·03	5·72	*tr.*	0·17=99·00

The bismuth determinations are regarded as somewhat low, an in (2) and (3) there was probably also a loss of lead. The genera formula derived $3PbS+Bi_2S_3$ is that of Kobellite, but the variet is interesting in containing a considerable amount of silver, whil the antimony is absent.—*Journ. Amer. Chem. Soc.*, vol. vii, No. 7

13. *Crystallographic Notes;* by OLIVER W. HUNTINGTON.—Mr. Huntington has made a study of the beautiful crystals o azurite from Clifton, Arizona. They resemble the crystals fro Chessy in habit, and agree closely in angles also, although no often admitting of the most exact measurement. They are quit highly modified although not adding to the already long list o known planes. The planes present were fifteen in number wit 001, 101 prominent.

The same writer gives the results of some measurements of th compound quartz crystals from Albemarle County, Virginia, de scribed by Prof. W. G. Brown in this Journal (Sept., 1884). H finds that out of a very large number of apparent twins the were only three cases in which the faces of two individuals fell abso lutely in the same zone, and in which an assumed twinning-plan could be referred to probable axial ratios. The possible twi ning-planes in these cases were $-\frac{2}{22}R$, $-\frac{2}{11}R$, $-\frac{7}{20}R$. The co clusion seems to be, therefore, that the grouping is rather acci dental, as in many other cases that have been described, tha according to a definite law.—*Proceedings of the American Acad emy of Arts and Sciences*, June 10, 1885.

14. *Mineralogical Notes;* by GEO. F. KUNZ.—In a paper rea before the Ann Arbor Meeting of the American Association fo the Advancement of Science, Mr. Kunz presented several point of interest in regard to American minerals. A description wa given of a pseudomorph from Magnet Cove, Arkansas, havin the form of trapezohedral crystals varying in size from 10 t 45 mm. They resemble the melanite of the same locality, bu so far as examined do not show the dodecahedral faces. Th color varies from yellowish-brown to grayish-white, and th specific gravity of the more compact specimens was 2·44 (nea that of leucite). Upon fracture an external shell separates fro a core of trapezohedral form. A microscopic examination b Mr. G. P. Merrill showed that the structure was homogeneou but for the most part spherulitic, though beyond the center the was a zone made up of radiating columnar bodies with indefinit outline; except in shape there was no distinguishing featu between the outer crust and the more compact interior. Th microscopic examination did not lead to any definite conclusio as to the original mineral. An analysis by Dr. F. A. Gent afforded (mean of two):

	SiO_2	Al_2O_3	Fe_2O_3	MgO	Na_2O	K_2O	H_2O
(½)	60·77	22·13	0·44	0·05	0·36	13·91	2·95=100·61

This is not very far from common orthoclase feldspar, and also approximates to the composition of leucite. The author suggests that it may be a case of feldspar pseudomorph after leucite, and calls attention to its similarity to the pseudomorphs of potash feldspar (and muscovite) after leucite from the Oberwiesenthal in Saxony. The case is by no means proved, however, and it is not improbable that the original mineral was the common garnet of the locality already alluded to.

The same author describes the Rumford tourmaline locality in Oxford county, Maine, at which rubellite, indicolite and green tourmaline have been obtained associated with fine scaly lepidolite, amblygonite, cassiterite and albite. From Raymond, Maine, fine specimens of essonite garnet have been obtained, some of them showing a dozen alternate layers of garnet and calcite; the breaking off at a layer of calcite leaves a fine dodecahedral crystal within. A beryl from Auburn, Maine, is mentioned, which is 30 cm. high and 22 wide and has 50 different layers, 25 of beryl, the others of albite, quartz and muscovite. The occurrence is noted of fine blue beryls near Mt. Anteros, in the Arkansas Valley, Chaffee County, Colorado, resembling those from Mourne Mt. in Ireland. From Salides, Colorado, large quantities of dodecahedral garnets have been obtained, which are coated with chlorite somewhat similar to these from the Lake Superior region.

The same author, in a recent paper before the New York Academy of Sciences, gives a number of notes in regard to the occurrence of minerals in the West. Some of them are as follows: The occurrence of fine malachite in large masses at the Copper Queen mine at Bisbee, Arizona, is mentioned; also specimens with crystals of calcite and malachite in large geodes, the latter mineral in fine acicular crystals 2 to 4 mm. long, giving a rich velvety surface; aurichalcite in beautiful tubes lining cavities comes from the same locality. The fine crystals of azurite from the Clifton mines, Graham County, Arizona, and also from the Longfellow mine are mentioned, as also the occurrence of chrysocolla at several localities, conspicuously at the old Globe mine in Gila County. Cuprite and dioptase from the Clifton mines, and cerussite for the Flux mine in Pima County and the Belle mine, Yavapai County, are alluded to.

15. *A Mt. Blanc Fulgurite.*—Mr. F. Rutley describes (Quarterly Journ. Geol. Soc., May, 1885) some specimens of hornblende gneiss having a fused surface, from the summit of the Dom du Gouté, "a small peak rising out of the snow at a height of 14,000 feet above the sea-level," belonging to the Mt. Blanc chain. The author speaks of the absence of crystallites in fulgurites (consequent on sudden cooling), and of their being, hence, the purest natural glasses ever formed.

Mr. Rutley examined also a specimen of the *bouteillenstein* or pseudo-chrysolite, of Moldauthein, in Bohemia, constituting nodules in sand, and in his conclusion says: that its glass enclosures and numerous gas-bubbles and its almost perfect freedom from

any products of crystallization render its comparison with fulgurite not merely admissible but possibly instructive."

The other localities of the material are tuffs in the neighborhood of Mt. Dore les Bains, Pessy in the Auvergne and one or two other localities.

16. *Fifth Annual Report of the State Mineralogist of California;* by H. G. HANKS. 235 pp. 8vo. Sacramento, 1885.—The mineralogical reports of California follow each other with admirable regularity and promptness. The present volume is largely filled with an account of the mineral exhibits from the different parts of the country at the New Orleans Exposition of last year.

III. BOTANY.

1. *Manual of the Botany (Phænogamia and Pteridophyta) of the Rocky Mountain Region, from New Mexico to the British Boundary.* By JOHN M. COULTER, Ph.D., Professor of Botany in Wabash College and Editor of the Botanical Gazette. Ivison, Taylor, Blakeman & Co. New York and Chicago, 1885. pp. 452.—The country lying west of the States which border the Mississippi and east of the great interior basin is becoming populous and full of schools. The Rocky Mountains, from the Yellowstone Park at the north to Colorado and the cooler parts of New Mexico, abound with intelligent summer visitors. The floral vegetation is copious and varied, and mostly with a character of its own. "This manual is intended to do for its own range what has been for a long time so admirably done for the Northeastern States by Gray's Manual." It is modeled upon that handy volume, with certain features caught from the Synoptical Flora. As was proper, it is the work of Professor Coulter, whose earlier essay in this field was the Synopsis of the Flora of Colorado, the most interesting and now best-known portion of Rocky Mountain Botany; and, as was natural, he has had some help from specialists, such as Mr. Bebb for the Willows (which amount to [illegible] 16 species), and Professor L. H. Bailey for the Carices, which mount up to 87 species, requiring very particular treatment.

This manual appears to be very well [illegible] and we may congratulate the author [illegible] presentation he has made [illegible] [illegible] a new field. The book was greatly needed, both for schools and [illegible]. To accommodate [illegible] on thin paper with [illegible] margins [illegible]. For educational [illegible] Gray's Lessons, by the same [illegible]. So we may now [illegible] this region [illegible] Professor Coulter's work, we regret that he has not [illegible] the names of received genera and species. [illegible] so much [illegible] Manual and in th[illegible]

Synoptical Flora; and it would be very useful, especially to beginners, who ought to have as little as possible to unlearn. If scientific education is to be creditable as well as popular, it is desirable that those who use botanical names should learn how to pronounce them, at least so far as to place the principal accent on the right syllable;—and this, indeed, is all that can be demanded.

In accordance with a prevalent mode, the Gymnospermæ are placed after Monocotyledones, thus separating them widely from other Dicotyledones. It is agreed that they should form a distinct class, and in the present collocation, Professor Coulter follows the weight of authority. But we do not allow that this collocation "better expresses relationships which have long been recognized." The only right series is that in which the Gymnosperms intervene between the Dicotyledons and the Pteridophytes; and the only way to preserve this series in a system is to begin (or end) with the Monocotyledones. But so long as we begin (or end) with Angiospermous Dicotyledons, and somewhere interpose the Monocotyledons, it is evidently more natural to keep the Gymnosperms next to the former, with which, through the Gnetaceæ, they are very closely connected, rather than to place them next the highest Cryptogams, with which (granting their descent) they are very distantly connected.

It was a good thought of the author to relegate all the introduced plants to foot-notes. Would it were practicable to do so in the Flora of the whole country, so that we could represent the vegetation of the land in its natural condition, before civilized man wrought change and confusion in geographical botany. The flora of the Great Plains and of the Rocky Mountains is, up to the present time, so little disturbed that the course here followed secures this advantage, and has no serious practical inconveniences.

A. G.

2. Sir Joseph Hooker on the last day of November retired from the directorship of the Royal Gardens at Kew, which he has held for twenty years, in continuation of the ten previous years in which he was Assistant Director under his father, Sir William Hooker. This is not a case of superannuation; for Sir Joseph is still a few years within the three score and ten, with mental vigor unbroken and the corporeal little diminished; but he finds it impossible to make satisfactory progress with the botanical works in hand while under the pressure of a load of official cares. He has fully borne his part of administrative duties, for which indeed he has remarkable aptitude; and working botanists—especially those of the tried old school and of needful experience—are rare and much to be treasured. One who knew Kew before Sir William Hooker took it in hand in 1839, and who has known it under his successor, and therefore through its whole development into the unexampled scientific and practical establishment it has been made under their hands, finds it difficult to conceive of Kew without a Hooker at its head. But we do not anticipate any falling off under the new Director, Mr. This-

selton Dyer, who has for a good number of years been Assistant Director, and for not a few of them the son-in-law of the botanist who now retires,—not from labor, indeed, but to the more steady prosecution of the work which the science expects from him. In this his colleagues throughout the world take a higher interest even than in the administration of the great institution which is known by the inadequate appellation of The Royal Gardens, Kew.

A. G.

IV. Astronomy.

1. *Meteors of November* 27, 1885.—On the evening of Nov. 27th, there was a remarkable shower of meteors radiating from Andromeda, and presumably connected with Biela's comet. In brilliancy it compares favorably with the magnificent display on the same day in 1872. In Europe and Asia the star shower was very remarkable wherever the clouds did not prevent its being seen. In this country it was nearly over before sunset, yet in the early evening the meteors were numerous enough to attract very general attention.

Mr. Robert Brown, of the Yale College Observatory, shortly after six o'clock, counted 44 in 24 minutes. About half of them left momentary trains. At half-past nine about a dozen were seen by three persons, Mr. Brown, Mr. Lyman Baird and myself. We estimated the hourly number for three observers, looking at the same part of the heavens, to be about 100. The radiation was in general from near γ Andromedæ with, however, some striking exceptions. Two or three left trains which were much less brilliant than those seen by Mr. Brown early in the evening. From 10^h 15^m to 10^h 30^m I counted 13, watching alone. Though several flights went sharply from near γ Andromedæ yet the radiation was not from any single point. One short flight had a broken appearance, much like the jagged line of an electric spark.

At Princeton, N. J.—Professor Young, in *Science*, reports 36 counted in a ten-minutes walk beginning at 7^h 15^m, and about a hundred before 7^h 45^m. From 7^h 45^m to 8^h, only three or four were seen. "The radiant was very well marked—an oval region about 4° long N. and S., and about 2° wide. Its center, according to the best estimate I could form, was about 2° N.W. from γ Andromedæ."

At Georgetown, D. C.—In *Science* are reported observations by two of Professor Hall's sons (and Mrs. Hall, who watched a short time), who counted 218 meteors between 6^h 30^m and 7^h 50^m; also the count of a party of four under charge of Mr. Horigan, viz: [illegible] between [illegible] and [illegible], [illegible] between 7^h 30^m and 7^h 55^m, [illegible] between [illegible] and [illegible], 28 between [illegible] and 9^h 0^m.

In England.—At Greenwich the rate of fall between 6^h and 7^h was measured at [illegible] to [illegible] per minute with remarkable average brilliancy. At [illegible] only [illegible] to [illegible] per minute appeared. The radiant was located at R. A. [illegible], Decl. [illegible] N. At Dundee, Mr.

James Lewiston reported 25 per minute for one observer at $5\frac{1}{2}^h$; at 6^h 100 in a minute were counted; at 6^h 20^m a decrease was noted; at 6^h 38^m they had risen to 70 per minute; thereafter the numbers gradually diminished. The radiant was fixed at R. A. 21°, Decl. 44°. Professor Pritchard at Oxford, counted 251 meteors between 6^h 34^m and 6^h 39^m, and 305 between 7^h 14^m and 7^h 19^m. Mr. G. J. Symons says that the meteors in 1866 were both more numerous and larger than in this shower. He computed the whole number falling at 8^h 5^m as over 3,000 per hour.

An adequate discussion of the shower can be made only when all the reports are received. H. A. N.

BOOKS RECEIVED.

Elements of Inorganic Chemistry, by James H. Shepard. 377 pp. 8vo. Boston, 1885, (D. C. Heath & Co.)

Chemical Problems, by Dr. Karl Stammer, translated by W. S. Hoskinson. 111 pp. 8vo. Philadelphia, 1885. (P. Blakiston, Son & Co.)

Handbook of Technical Gas-analysis, by Carl Winkler, translated with a few additions, by George Lunge. 125 pp. 8vo. London, 1885. (John Van Voorst.)

New Theories of Matter and of Force, by William Barlow. 395 pp. 8vo. London, 1885, (Sampson, Low, Marston, Searle & Rivington.)

Mineral Resources of the United States, Calendar years 1883—'84, by Albert Williams, Jr. 1016 pp. 8vo. Washington, 1885.

Gravity Research: 1. Use of the Noddy for measuring the swaying of a pendulum support. 2. Effect of the flexure of a pendulum upon its period of oscillation, by C. S. Peirce, (Appendices Nos. 15 and 16 of the Report of U. S. Coast and Geodetic Survey for 1884.) Washington, 1885.

Index to Literature of Uranium, 1789–1885, by H. Carrington Bolton. 36 pp. 8vo. Washington, 1885, (Smithsonian Report for 1885.)

Recueil de Monographies Stratigraphique sur le Système Crétacique du Portugal, par Paul Choffat. Contrée de Conte, de Bellas et de Lisbonne. 68 pp. 4to, with 3 plates. Description de la Faune Jurassique du Portugal. Mollusques, Lamellibranches, Deuxième order, Asiphonidæ; by the same. 36 pp. 4to, with 10 plates Lisbon, 1885.

Report on the Invertebrata of the Laramie and Cretaceous rocks of the vicinity of the Bow and Belly Rivers, by J. F. Whiteaves. Contributions to Canadian Palæontology, vol. i, Part I, Geol. and Nat. Hist. Survey of Canada. 90 pp. 8vo. with 11 plates. Montreal, 1885 (Dawson Brothers.)

On new Cretaceous Fossils from California, by Charles A. White. 14 pp. 8vo. with 5 plates. Washington, 1885, (Bulletin of the U. S. Geological Survey, No. 22.)

Results of Ornithological Explorations in the Commander Islands and Kamtschatka, by Leonhard Stejneger. 382 pp. 8vo. with 8 colored plates. Washington, 1885, (Bulletin of the U. S. National Museum, No. 29.)

A Revision of the Astacidæ, by Walter Faxon, Part I. The Genera Cambarus and Astacus. 186 pp. 4to, with ten plates. Cambridge, 1885, (Memoirs of the Museum of Comparative Zoology, at Harvard College, vol. x, No. 4.)

The Development of Osseous Fishes. I. The Pelagic stages of young fishes, by . Agassiz and C. O. Whitman. 56 pp. with 19 plates, (Studies from the Newport Marine Laboratory: Memoirs of the Museum of Comparative Zoology at Harvard College, vol. xiv, No. I, Part 1.)

Larval Theory of the Origin of Cellular Tissue, by Alpheus Hyatt. pp. 45–53 of vol. xxiii of the Proceedings of the Boston Society of Natural History, arch 5, 1885.

Bulletin of the Washburn College Laboratory of Natural History. Vol. I, No. ; pp. 113–148.

Bulletin of the American Museum of Natural History. Vol. I, No. 6. pp. 181–5, with plates xix to xxii.

Bulletin of the Illinois State Laboratory of Natural History. Volume II, pp. 141–255, 8vo, contains Article III, on the Parasitic Fungi of Illinois, Part 1, by T. J. Burrill.

Second Annual Report of the Agricultural Experiment Station of the University of Wisconsin, for the year of 1884. 112 pp. 8vo. Madison, 1885. Bulletin No. 7, October, 1885. Experiments in Calf-feeding; The Cooley system of creaming milk.

Annual Report of the Board of Directors of the Chicago Astronomical Society together with the Report of the Director of the Dearborn Observatory. 16 pp. 8vo. Chicago, 1885. This report contains observations on the planet Jupiter from Sept., 1884, to July, 1885; the descriptions are accompanied by two plates.

Bibliographies of American Naturalists. II. The published writings of Isaac Lea, LL.D., by Newton Pratt Scudder, 278 pp. 8vo, with a portrait of Dr. Lea. Washington, 1885. (Bulletin of the U. S. National Museum, No. 23.)

The Annals of the Cakchiquels: The original text, with a translation, notes and introduction by Daniel G. Brinton. 234 pp., 8vo. Philadelphia, 1885. (Brinton's Library of Aboriginal American Literature, No. VI.)

The Races of Britain: A contribution to the Anthropology of Western Europe, by John Beddoe. 271 pp. 8vo, with an appendix. Bristol and London, 1885. (Scribner & Co.)

Report of the Superintendent of the U. S. Coast and Geodetic Survey; showing the progress of the work during the fiscal year ending with June, 1884. 621 pp. 4to, with 23 maps. Washington, 1885.

Report of the International Polar Expedition to Point Barrow, Alaska. 695 pp. 4to, with numerous plates. Washington, 1885.

Memoirs of the National Academy of Sciences, Vol. III, Part 1, 110 pp. 4to, with 6 plates. Washington, 1885. This volume contains eight Memoirs, by the following authors: G. K. Gilbert, S. P. Langley, A. M. Mayer, C. F. Chandler, C. S. Peirce and J. Jastrow, S. H. Scudder, E. D. Cope, A. S. Packard.

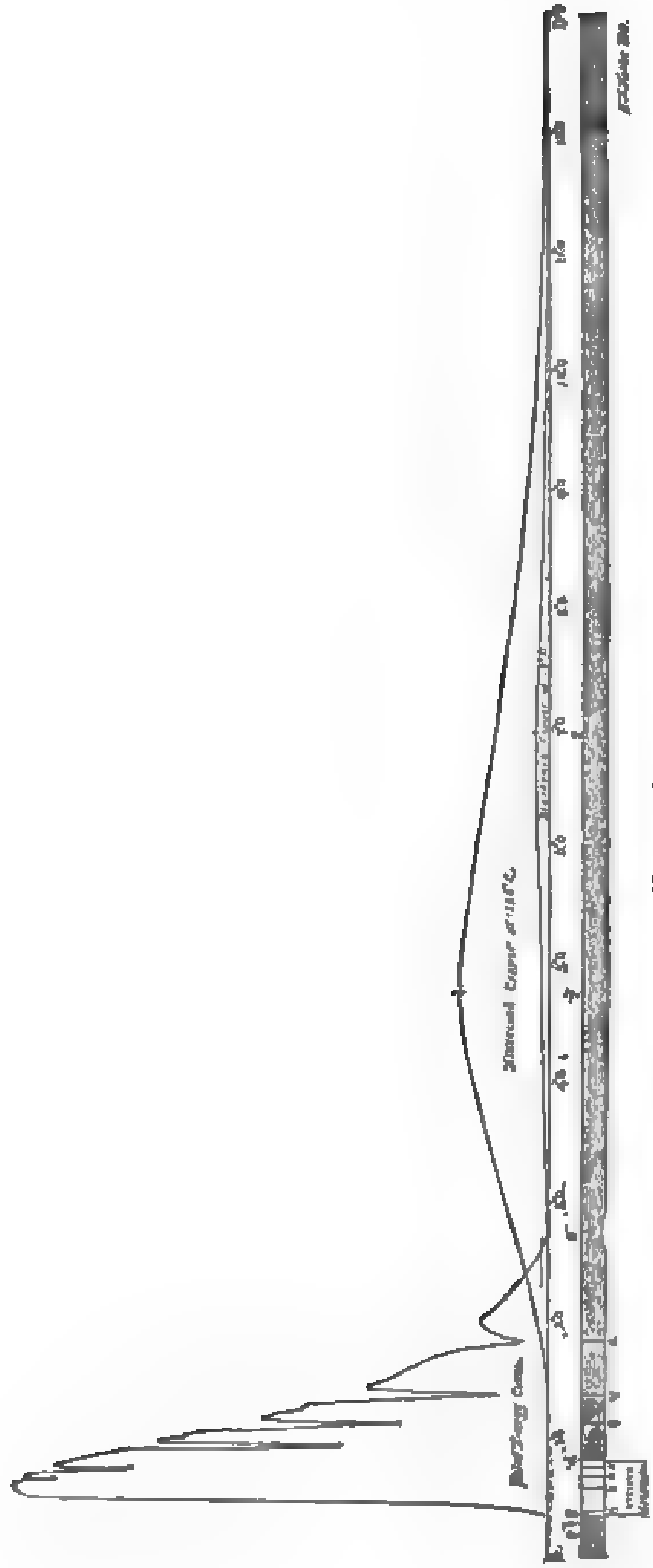
Water Meters, by Ross E. Browne, and The Preservation of Timber, by S. B. Boulton. Nos. 81 and 82 of Van Nostrand's Science Series, (Reprints from Van Nostrand's Magazine.)

Anales de la Oficina Meteorologica Argentina, por su Director Benjamin A. Gould. Tomo IV, 600 pp. 4to. Buenos Aires, 1884.

Lectures on the Principles of House Drainage, by J. Pickering Putnam, Architect. 125 pp. 12mo. Boston, 1886. (Ticknor & Company.)

OBITUARY.

DR. JOHN CHRISTOPHER DRAPER, Professor of Chemistry in the Medical Department of the University of the City of New York, died in New York, on the twentieth of December, in his seventy-first year. Dr. Draper was the eldest son of the eminent Professor John W. Draper. His scientific papers, apart from those in the Science of Medicine, are devoted to Chemical and Physical subjects; and among the latter, chiefly to optical phenomena. His last two, relating to dark lines in the solar spectrum, are contained in volumes of this Journal for 1878 and 1879. He is the author also of a Practical Laboratory Course in Chemistry, and a Text-book on Medical Physics, the latter work only recently issued. He became Professor of Chemistry in the Medical Department of the University of the City of New York, in the year 1866, and was [illegible] rank among the medical [illegible]. He received the degree of Doctor of Laws from [illegible] College, [illegible].



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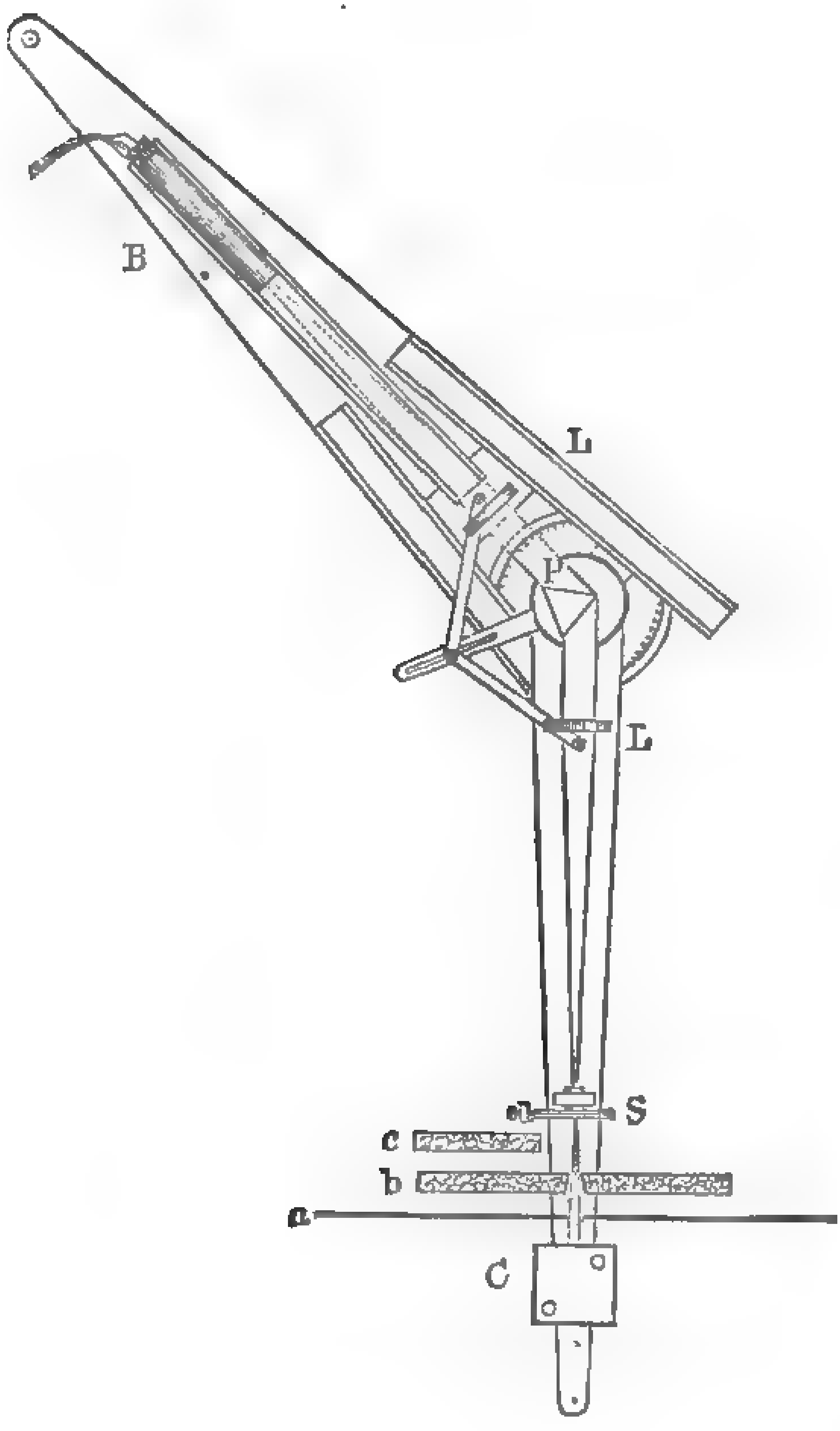
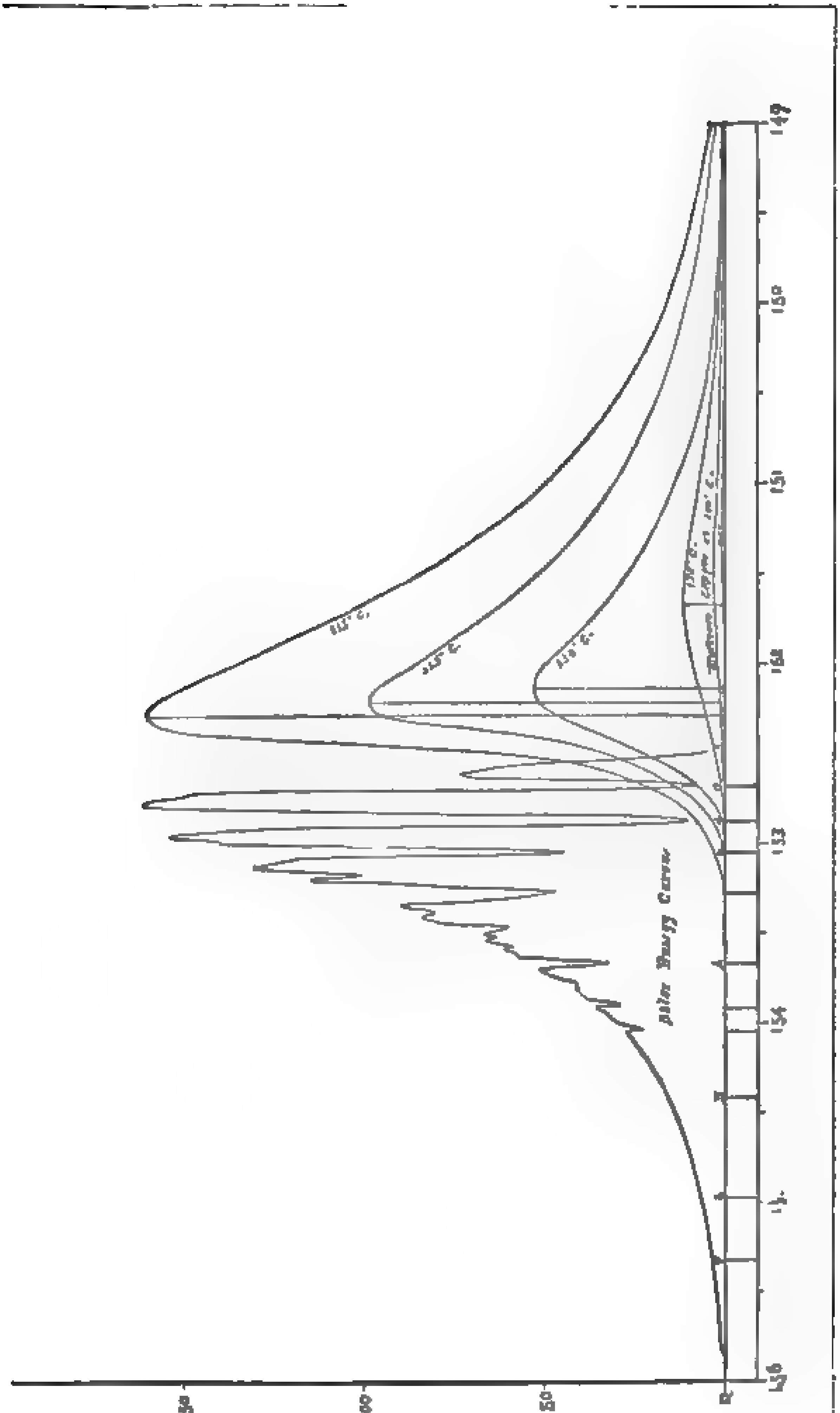
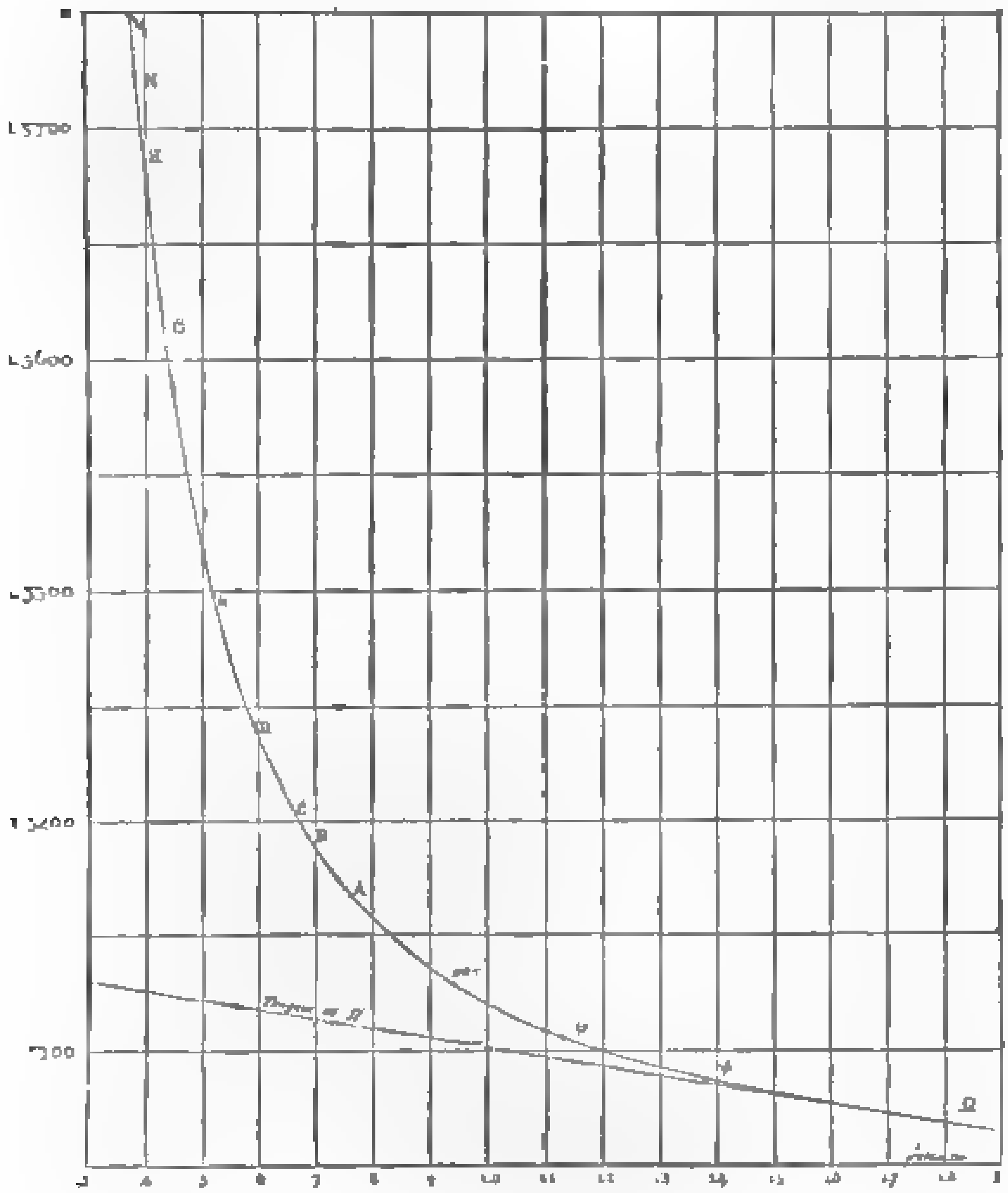


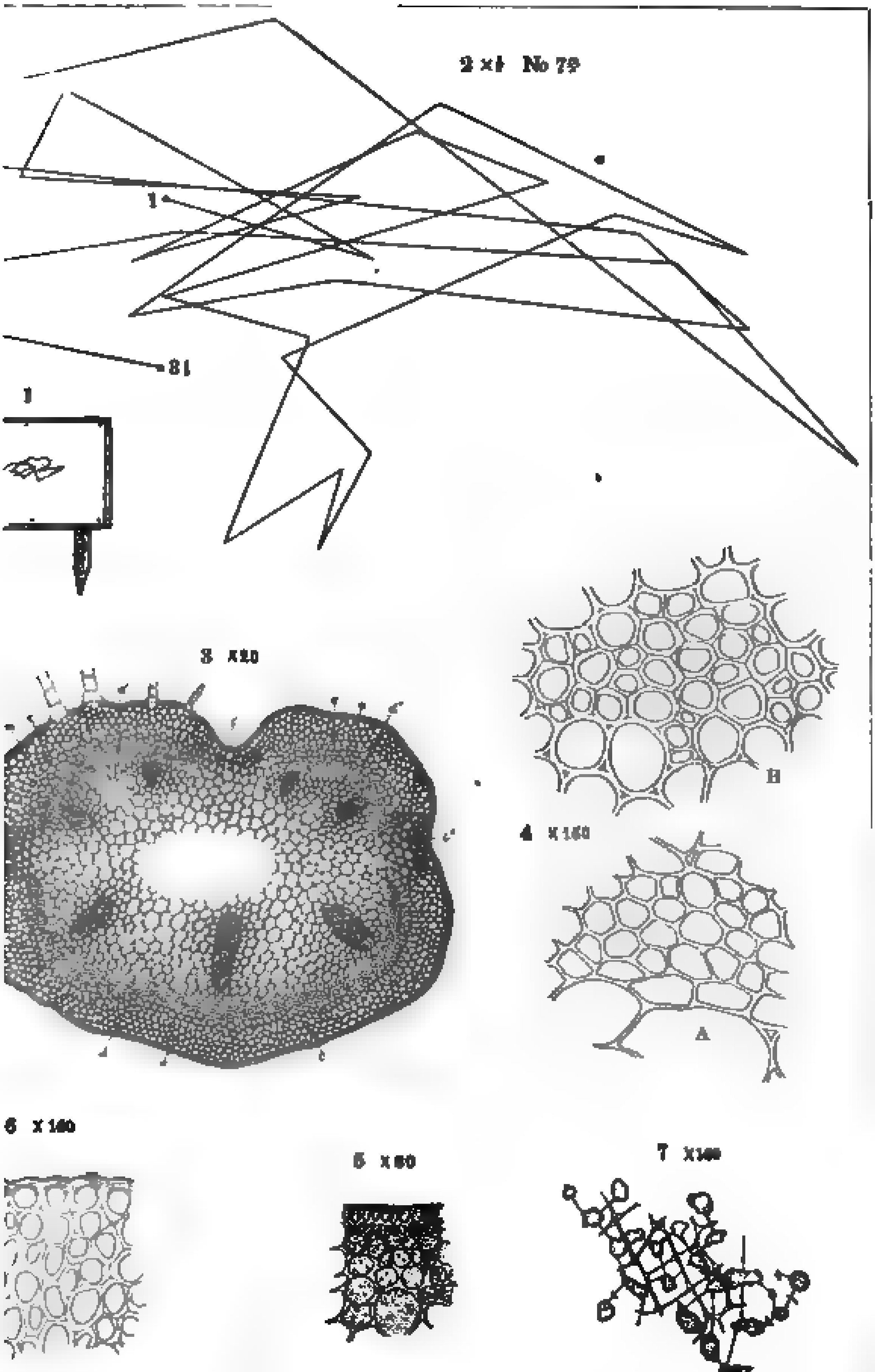
Spectro-Bolometer with Rock Salt Train.



PRISMATIC SPECTRUM.



Showing $n = f(\lambda)$ for Rock Salt



ig. 1 Registration board. 2 Movement of tendril No. 7*a* reduced to one-half
ıal size 3. Cross section of tendril arm, showing the tissue during the active
ıod *a*, *a′*, *a″*, Collenchyma. *b*, *b′*, *b″*, Vibrogen tissue. *c*, *c′*, *c″*, Thin walled
enchyma filled with protoplasm and some chlorophyl. *d*, *d′*, *d″*, Concentric
ıd of wood tissue × 20. 4. Wood tissue as shown at *d*, *d′*, *d″* × 160 ; A, Grow-
; wood cells as they appear during the active period. B, The same wood cells
ry much thickened, as they appear after motion has ceased 5 Vibrogen
sue as seen at *b*, *b′*, *b″* × 80. 6. Collenchyma tissue, as seen at *a*, *a′*, *a″* × 160.
Continuity of the protoplasm in the collenchyma tissue, obtained by treatment
th concentrated H_2SO_4 and stained with picric aniline × 160.

THE

AMERICAN JOURNAL OF SCIENCE.

[THIRD SERIES.]

ART. VII.—*The Story of Biela's Comet, a Lecture delivered by* H. A. NEWTON, *March* 9, 1874, *at the Sheffield Scientific School of Yale College.**

LADIES AND GENTLEMEN: I ask you to listen to-night to the story of Biela's comet. I will weave into the story enough of astronomy to justify its place in this course as a lecture.

The story has none of the interest which human passions give to stories of human life, and yet if it shall not be to you as interesting as a novel, it will be because I shall spoil the story in telling it to you. It is a true story. In other words, I mean to separate sharply what we know from what we guess.

One hundred and two years ago last night (March 8, 1772) a Frenchman named Montaigne, in the provincial City of Limoges, found a comet. He did what little he could with his small telescope to mark its place in the heavens, but it was not much that he could do. The comet was a faint one, not to be seen by the naked eye, and had a short tail, only one-eighth as long as across the disk of the moon. He did not dream that that little foggy speck of light was to be one day one of the most interesting comets in the solar system; in fact, that he himself was to be known to history only for having first seen it. This little comet is the hero of my story—a hero from humble life. Montaigne wrote to Paris of his discovery, and they saw it three or four times before it disappeared.

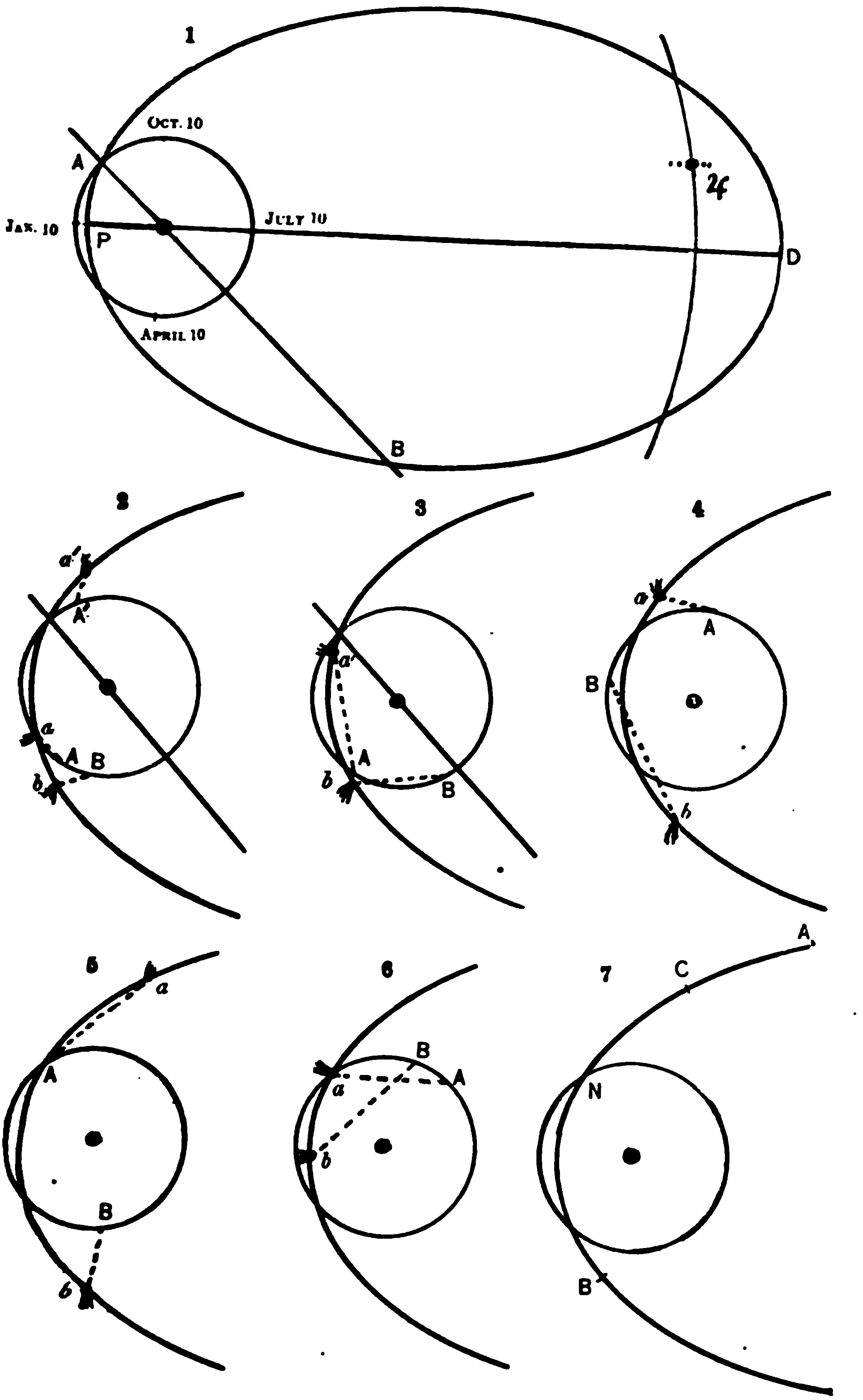
* The renewed interest in Biela's comet created by the great shower of meteors on the 27th of November last, justifies giving space for this lecture.—(EDS. JOUR. SCIENCE.)

Thirty-three years later, November, 1805, another Frenchman named Pons, saw the comet. It passed rapidly from the northern heavens, and in a month went below our horizon. It came this time very close to the earth, and I shall in a moment tell you how it appeared. It was visible to the naked eye, even in strong moonlight. Twenty years later, February 1826, an Austrian officer, Von Biela, again found the comet. So soon as an orbit could be computed, it was seen that the three comets of 1772, 1805 and 1826 were the same body. This has since been known as Biela's comet. Its exact path around the sun could now be told. Let me show it to you.

Let us look down upon the solar system from a point several hundreds of millions of miles north of it. Looking southward we should see the sun in the center. The earth, with its moon, would travel around the sun in a path or orbit denoted by the circle in the figure (fig. 1).

It goes about the sun once a year, being, on the 10th days of January, April, July and October, at the points so marked on the diagram. The motion is opposite to that of the hands of a watch. Outside, five times as far from the sun as is the earth, will be the huge planet Jupiter, a part of whose path you see. It goes about the sun once in twelve years. The paths of the other planets are not in the figure,.as I have nothing to say about them to-night. In the figures which I show you the earth's orbit is twenty inches in diameter, or one inch to nine million miles. An express railway train traveling all the time for a fortnight would pass over about the thousandth of an inch in this figure. The comet's path is the ellipse. Around this ellipse it traveled three times in twenty years, or once each 6⅝ years. When nearest to the sun, or at perihelion, it went within the earth's orbit, and when most distant it passed beyond Jupiter.

The comet's motion is very unequal. At D it moves very slowly. As it falls toward the sun the sun's attraction makes it move faster and faster, so that it whisks rapidly by P. As it then rises from the sun on the other side of the orbit, the sun not only turns it ever out of the straight path it would move in, but it stops its upward momentum, so that when it reaches D again it has only its old velocity with which to repeat its circuit. At P its velocity is twenty-eight miles, at D four miles, a second. In fact, to pass over the part lying apparently outside of Jupiter's orbit, just half of the whole 6⅝ years is required. I said *apparently* outside, for another fact must be noticed: while Jupiter and the earth may be said to move in the same plane, that of the figure, the comet's orbit, lies at an angle. Suppose the ellipse to be a metal ring, and let it turn about the line AB as a hinge, the part ADB ris-


1
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ing toward you, and the part APD retreating from you. parts near D must rise about the half-diameter of the ea: orbit to give the true position of the two planes. Notice the comet's and the earth's orbits cut each other at the nod the line AB. The importance of this fact will by and by pear. The two orbits seem to cut each other at another p (below P), it is true, but because of the angle of the planes cutting is only apparent.

Like all other comets, this one was visible only when i the earth and near the sun. Through the outer part of its j it was never seen, even with a telescope. The comet was : in 1826 for the third time.

Positions in 1772 *and* 1805.—In March, 1772, it was first : from A in the direction A*a* (fig. 2). It was last seen i weeks later from B in the direction B*b*. In November, 1! Pons found it when the earth was at A′ and the comet a (fig. 2). Both the earth and the comet were going to the n the comet going faster than the earth. The earth pa: the node just ahead of the comet. I have told you that comet was then visible to the naked eye even in moonli; and well it might be. On the 8th of December, with the s of the figures before you, it was only $\frac{3}{8}$th of an inch from earth at the node. On the same scale the moon is $\frac{1}{40}$ of inch from the earth. The comet passed $\frac{1}{16}$ of an inch out the earth's orbit, but the earth was already past that point.

Dr. Schröter describes the comet: To the naked eye it (Dec. 8) a large round cloud of light nearly as large as moon. In a 13-foot telescope it had the same appeara though it was much smaller, and it had a bright, star-l nucleus. This nucleus had not sharp edges, not even a c nitely round form, but was like a light shining through a i Its diameter was about 112 miles, or, if we take only the c tral light, 70 miles; speaking roughly, as large as the Stat Connecticut. The whole cloud, as seen in the telescope, some 6,000 miles in diameter; to the naked eye perhaps 30, miles. How much smaller than 70 miles was the hard par the nucleus, we cannot say.

Position in 1826.—In 1826 it was first seen from A'in line A*a* (fig. 3). Astronomers followed it with care, as t had come to know that it was a comet of short period, and many such were then known. Its path then crossed just in the earth's orbit at the node, but only $\frac{1}{500}$ of an inch in diagram, or 20,000 miles, in fact, from it.

Position in 1832.—Six and two-thirds years brings us to 1! and you can readily imagine with what interest this first dicted return was watched for. Some of you also remem the wide-spread, though groundless, fears at that time of a

lision of the earth and the comet. The comet was first seen by Sir John Herschel in September. In his 20-foot reflecting telescope he saw it pass centrally over a group of small stars of the 16th or 17th magnitude. The slightest bit of fog would have at once blotted out the stars. Through the comet, however, they looked like a nebula, resolvable, or partly resolvable, into stars. How thick the cometic matter was we do not know. Its extent, laterally, was not less than 50,000 miles. Again M. Struve saw it pass centrally over a star of the ninth magnitude. A like star was seen in the telescope at the same time, so that he was able to say that the comet did not dim in the least the one which it covered. The comet, as the figure (fig. 4) shows, was in 1832 always at a great distance from the earth.

Another six and two-thirds years brings us to 1839. The comet came to perihelion, at P, in July. The earth and comet were on opposite sides of the sun both before and after July, and of course the comet was not seen.

Position in 1845.—Another circuit was finished in 1845–6. The comet was visible then during five months, from *a* to *b* (fig. 5), or as viewed from the sun through nearly half its circuit. At this time it was that the comet became all at once famous.

On the 29th of December Mr. Herrick (then Librarian of Yale College) and Mr. Francis Bradley (then in the City Bank) were watching the comet through the Clark telescope in the Atheneum tower yonder. They saw a small companion comet beside the larger one! What did it mean? Had the comet a satellite like the earth's moon? Or had the comet been split by some convulsion? Two weeks later the companion comet was seen by Lieut. Maury and Professor Hubbard at Washington, and two days after that, it was seen by two or three European astronomers.

Changes were seen in the larger telescopes that increased the mystery. The faint companion grew in size and brilliancy. Each comet threw out a tail. Then the smaller one had two tails. Then the larger one had a pointed, or diamond-shaped, rather than a round head. Two nuclei were seen in the larger one, and it also had two tails. An arch of light was thrown over from one to the other. For some days in February the companion was the brighter of the two. Presently three tails were seen running from the primary, and three cometary fragments (one observer says five) around its nucleus. What could it all mean? Do you wonder that astronomers were excited by these wizard changes?

The companion comet was seen in Washington by Maury and Hubbard two weeks after it was seen here by Herrick and Bradley. Professor Joseph Hubbard was the son of a resident

of New Haven, well-known to many of you from his connection with the New Haven Bank. Professor Hubbard was graduated two years before (in 1843) at this college, and was now Professor in the Naval Observatory at Washington. He took up the study of the motions of the two Biela comets as special work, outside of his hours on duty. How faithfully he worked, four thick manuscript volumes of figures might tell. I cannot show you those books. They form, since Professor Hubbard's death, a cherished memento in the possession of a friend. But I have brought another of Hubbard's volumes from the College Library, one of three upon the comet of 1843, in order to show you by what patient labor some of the results of astronomy must be wrought out. In your school days you called it a wondrously long sum that covered both sides of the slate. On the leaves of this book there are as you see one, two, three, and in some cases, I think, even four thousand figures upon the page. You will, I am sure, excuse me from telling in detail to-night, how we learn about the sizes, distances, and motions of the comets. Eight or ten such volumes of figures, to be increased in time, we hope, by the four Biela volumes, form a monument to a true, devoted, gentle scholar of science. You will not wonder when I tell you that he hated shams.

Positions in 1852.—In 1852 the comet was always at a great distance from the earth (fig. 6), and only to be seen through the largest telescopes. The changes of size and brightness of the two comets were remarkable, and as they could but just be seen, sometimes one and sometimes the other alone was visible; which one it was that a person saw at any time was only told by computation afterward.

The two comets were now eight or ten times as far apart as they had been seven years before. They were at the point P, 1,250,000 miles apart. Professor Hubbard found that he could not tell which comet of 1852 was preceding and which following, in 1845. One supposition agreed as well with the observations as the other.

Perhaps the knowing ones among you have noticed that the arc from the node to the point marked Jan. 10, in the first diagram is too large for one month, for in 1772 the earth passed the node Dec. 9. But you will notice that when the comet is at D, and the large planet Jupiter is near by, he draws the comet toward the plane of the figure. The result is to bring the comet down to meet the earth's orbit farther from P. The node thus went back from Dec. 9 to Nov. 27, a distance of 12 days, or 12 degrees in the circle. The figure represents this last orbit. By the same cause the inclination was reduced one fourth, or from 17° to 12°.

Since September, 1852 (with one doubted exception to b

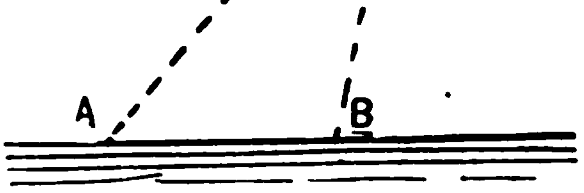
oken of), neither of the two Biela comets has been seen. 1859 their path was to us behind the sun. In 1866 they ould have been at the point P on the 26th of January. A etter chance of seeing them could hardly be. They were at l times to be away from the sun's light, and when nearest to e earth not more than one-fifth the sun's distance. The paths ere carefully computed, and the action of all the planets, notaly that of Jupiter, allowed for. A dozen observers for months wept the heavens with their telescopes, but not the slightest race of the comets was seen.

Again, they should have come to perihelion a year ago last utumn (Oct. 6, 1872), but, as I suppose, neither of them was een. With the loss of its hero, our story would seem to come o an end. I must ask your indulgence, however, for another hapter.

I suppose that each one of you has often seen a shooting star. On a clear night you have seen a bright point of light travel uickly across the sky, as though a star had been shot from its lace in the firmament. It may, if it was a large one, have roken into sparks as it disappeared, or have left a cloudy train long part of its path for an instant; or perhaps it was so faint ven that you could not be quite sure that you saw anything. Some of you have seen those shooting-stars by hundreds in tar showers.

Until near the close of the last century, poets dreamed, and ther men guessed, about these objects, but knew nothing. Two German students, Brandes and Benzenberg, found out, and told us, hat these bright flights were in he upper parts of the atmosphere. From the two ends of the city a rack always appeared to be in the ame part of the heavens. But when ne went to a village many miles way, a track was seen by the wo persons (at A and B, figure), in different parts of the sky. Hence they were able to measure the eight of the shooting stars from the ground.

8.



We now know that these luminous paths are rarely less than) miles or more than 90 miles from the earth. We also know at any shooting-star was a small body, of unknown size, perps not larger than a pebble or a grain of coarse sand even, doubtedly solid, which has been traveling around the sun in own independent orbit, like any planet or comet. Its path me within 4,000 miles of the earth's center, and so the small dy struck into the earth's atmosphere. Its velocity was so

great—fifty or a hundred times that of a cannon ball—that ever in our rare upper atmosphere an intense light and heat was developed by the resistance, and the body was scattered in powder or smoke. These bodies before they come into the air I call meteoroids. It is only when they have reached our atmosphere and begin to burn that we ever see them. They are then within 90 miles of the ground.

Brandes, one of the two German students spoken of, was riding in an open post-wagon on the night of Dec. 6, 1798, and saw and counted hundreds of these shooting stars or meteors. At times they came as fast as six or seven a minute. These meteors which Brandes saw that night we know now were bits from Biela's comet. In November, 1833, occurred the famous star shower, which some of you saw. The facts of that shower gave to two New Haven men, Professor Twining and Professor Olmsted, the clue to the true theory of the shooting stars. From that date shooting stars have belonged to astronomy. The November meteors were admitted a new constituent of the solar system. Three years later, M. Quetelet, of Brussels, found that shooting stars are to be seen in unusual numbers about the 10th of August of each year. A few months afterwards Mr. Herrick made independently the same discovery, but he also told us of star showers in April and January. What Brandes had seen in December, 1798, led Mr. Herrick, moreover, to expect a like shower in other Decembers, and he asked that shooting stars be looked for on the 6th and 7th of December, 1838. This shrewd guess was justified, for on the evenings of those days hundreds of these meteors were seen in America, in Europe, and in Asia by persons thus induced to look for them. These shooting stars also had once been parts of Biela's comet, though this fact was not dreamed of at that time.

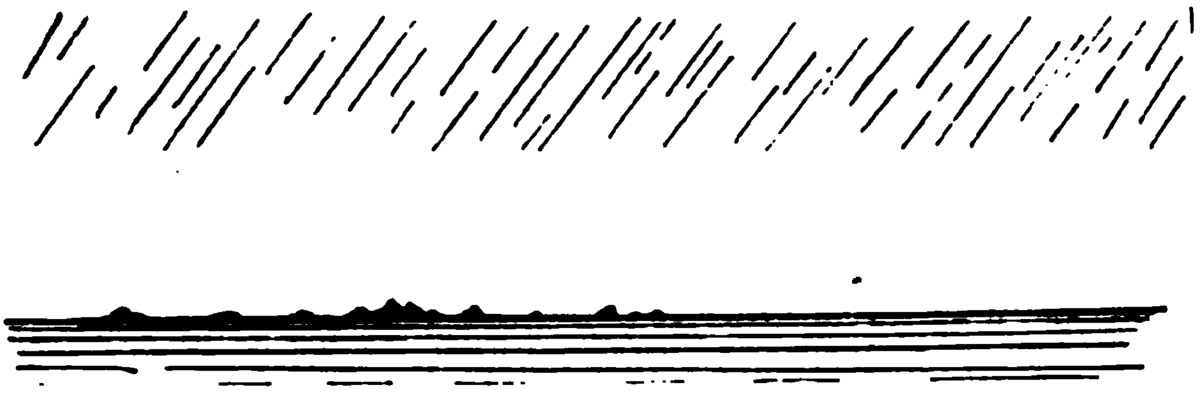
In the course of time we came to know more about the meteoroids; that in general they moved in long orbits like comets, rather than round ones like planets; that some of them were grouped in long, thin streams, many hundreds of millions of miles long, and that it was by the earth's plunging through these that we have star showers; that the space traveled over by the earth has in it everywhere some of these small bodies, probably the outlying members of hundreds of meteoroid streams.

Also the periodic time and the path of the stream of November meteoroids were found out. Then came the interesting discovery that in this stream, and in that of the August meteoroids, lay the paths of two comets. Then Dr. Weiss of Vienna showed that the meteors seen by Brandes in 1798, and by Herrick in 1838, as well as many meteors seen near Decem

ber 1 of other years, and the Biela comets, all belonged to each other.

It is then properly a part of my story to show you the behavior of one of the streams of meteoroids. Standing several hundreds of miles away, see them enter the upper atmosphere. They are entirely unseen until they strike the air. They then

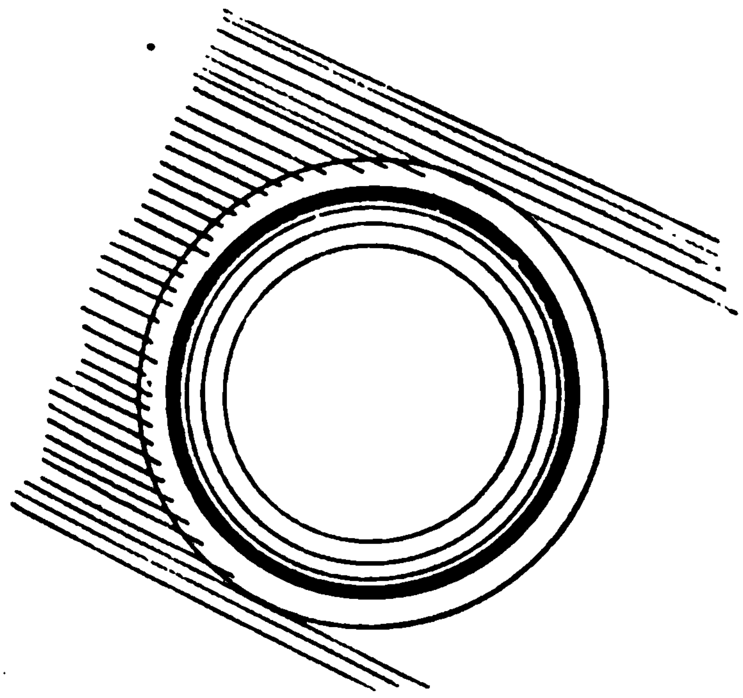
9.



come down like drops of fiery rain a few miles, in parallel lines, burning up long before they reach the ground (see fig. 9). The air is in fact a shield, protecting the men below from a furious bombardment. The region of the luminous tracks is many miles above that of the highest mountains.

Go farther away. Parallel lines may show the paths of the meteoroids, though the bodies themselves are too small to be seen. They strike a little way into the air, to some persons coming from the zenith, to some coming obliquely, to some skimming through the upper air—and unseen by all upon one whole hemisphere. I need hardly remind you that sunlight, and twilight, and clouds often come in to prevent the seeing of the star-flights by persons below.

10.



Go still farther away. From outside look in toward the sun upon the earth and meteoroid stream. The meteoroids in fact are not to be seen. The stream is of unknown depth, perhaps millions of miles deep. Its density increases in general toward the center. We cross the densest part of the November stream in two or three hours, and the whole of it in 10 or 15 hours, while the passage of the August stream requires three or four days. The Biela stream is crossed obliquely, the meteoroids overtaking the earth. The August stream is nearly perpendicular, and the November stream meets the earth.

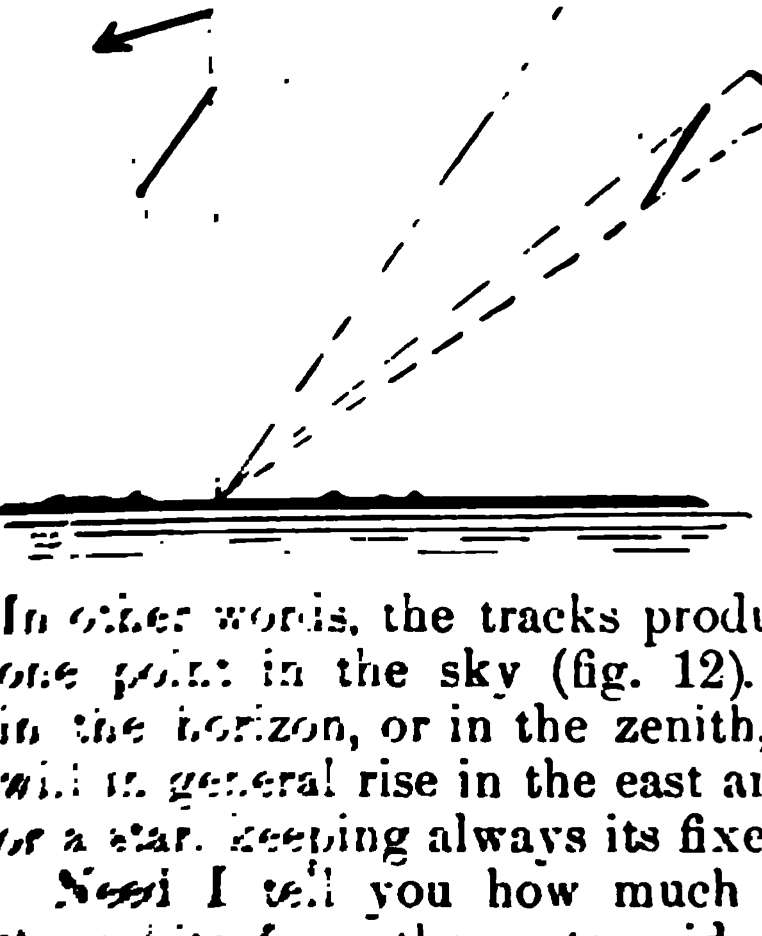
Again go still farther away, out to the point from which we first looked down upon the earth and comet. We then see (by

the mind's eye) the meteoroids strewn along the elliptic orbit of the comet for hundreds of millions of miles, forming a stream of unknown breadth, but in the scale of the first figure shown you, about $\frac{1}{50}$ of an inch in thickness.

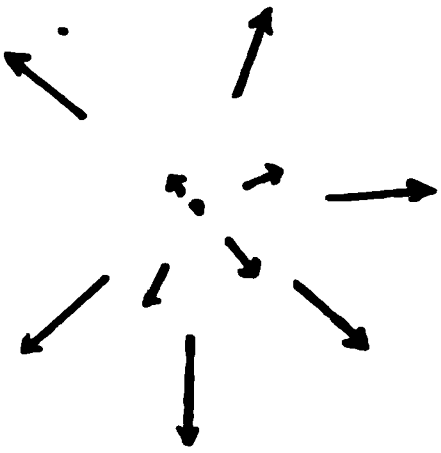
Come back now and stand inside the stream, at its densest part. You in fact see nothing; but the meteoroids are all about you scattered quite evenly, and distant each from its nearest neighbors 20 or 30 miles. They all travel the same way and with a common motion.

Once more change your place and look up from the earth's surface. The meteoroids can now be seen, for when they strike the air they burn with intense light, becoming shooting stars. As it is from this position only that we ever see them, note their behavior with more care. A shooting star coming toward you appears only as a bright stationary point in the sky. That point is a marked one in every star shower, and is called the radiant. The meteors to the right and left of the stationary one are, in fact, moving in the common direction, but they seem to move in the sky away from the radiant (fig. 11).

11.



12.



In other words, the tracks produced backward will all meet i one point in the sky (fig. 12). This radiant point may b in the horizon, or in the zenith, or at any place between. will in general rise in the east and set in the west, like the su or a star, keeping always its fixed place among the stars.

Now I tell you how much we would like to have some these bits from the meteoroid streams to handle, to try wit the blowpipe and under the microscrope, perhaps thus to lear something of their history? We do have something like thi times large meteor masses come crashing into the air. The with a light bright enough to be seen over several State down usually a little lower than the shooting star frequently to a height of 25 or 30 miles, they break a noise like the firing of heavy artillery, to be heard ov counties. Fragments scattered in every direction f ground over a region ten or twenty miles in extent.

show you several such fragments. There are over a hun-
d of them in our college cabinet, one of which weighs nearly
n.

ietween these stone-producing meteors and the faintest
oting star I cannot find any clear line of division. We
e meteors that break with a loud detonation, but no frag-
its are seen to fall. One such was seen in 1860 from
sburgh to New Orleans, and from Charleston to St. Louis.
xploded over the boundary line of Tennessee and Kentucky.
have others which are only seen to break into pieces, no
e being heard. Then we have those which quietly burn
Like the larger ones, these may leave smoky trains that
for minutes. One such I have seen for 45 minutes as it
ly floated away in the currents of the upper air.

'hus through the whole range, from the meteors that give
hese stones and irons for our museums, down to the faintest
oting star hardly seen by a person watching for it, we pass
the smallest differences. They differ in size, in color of
ne, in direction, in train, in velocity. But in astronomical
racter all seem to be alike. They move in long orbits like
nets, and like comets at all angles to the earth's orbit. In
, a meteoroid is a small comet, not having, however, the
net's tail.

et us turn from this long digression again to the story of
la and tell you what we saw of it in November, 1872. We
ourse looked for a few fragments from the comet the last
k in November, but not quite as early as the 24th. But on
t evening they came, in small numbers it is true. Before
lnight we saw in New Haven about 250 shooting stars,
e-fourths of them from Biela. Very few of them were to
een the next morning and evening. Then for a day or two it
cloudy. But in the early part of the evening of the 27th
came upon us in crowds. Over 1,000 were counted in an
r. By 9 o'clock the display was over. But we saw only
last few drops of a heavy shower. Before the sun had set
us the shooting stars were seen throughout all Europe,
ing too fast to be counted. At least 50,000, perhaps
,000, could have been seen then by a single party of
rvers.

otice what was really seen. Here is a chart of the paths
he shooting stars as actually seen on that evening, and
vn with care at the time upon maps of the stars. You see
w stray flights cutting wildly across the others. These are
ngers to the system.

ou see also that the paths do not, as we had reason to
ect, all meet in one point. This is not due to errors of
erving, for we see it in every star-shower. It is probably

because the small bodies glance as they strike the air, just as a stone skips on the water. In fact, we often see the meteors glance in the air—the paths being crooked.

The meteors came from the northern sky. A German astronomer, Professor Klinkerfues, at once thought that if this

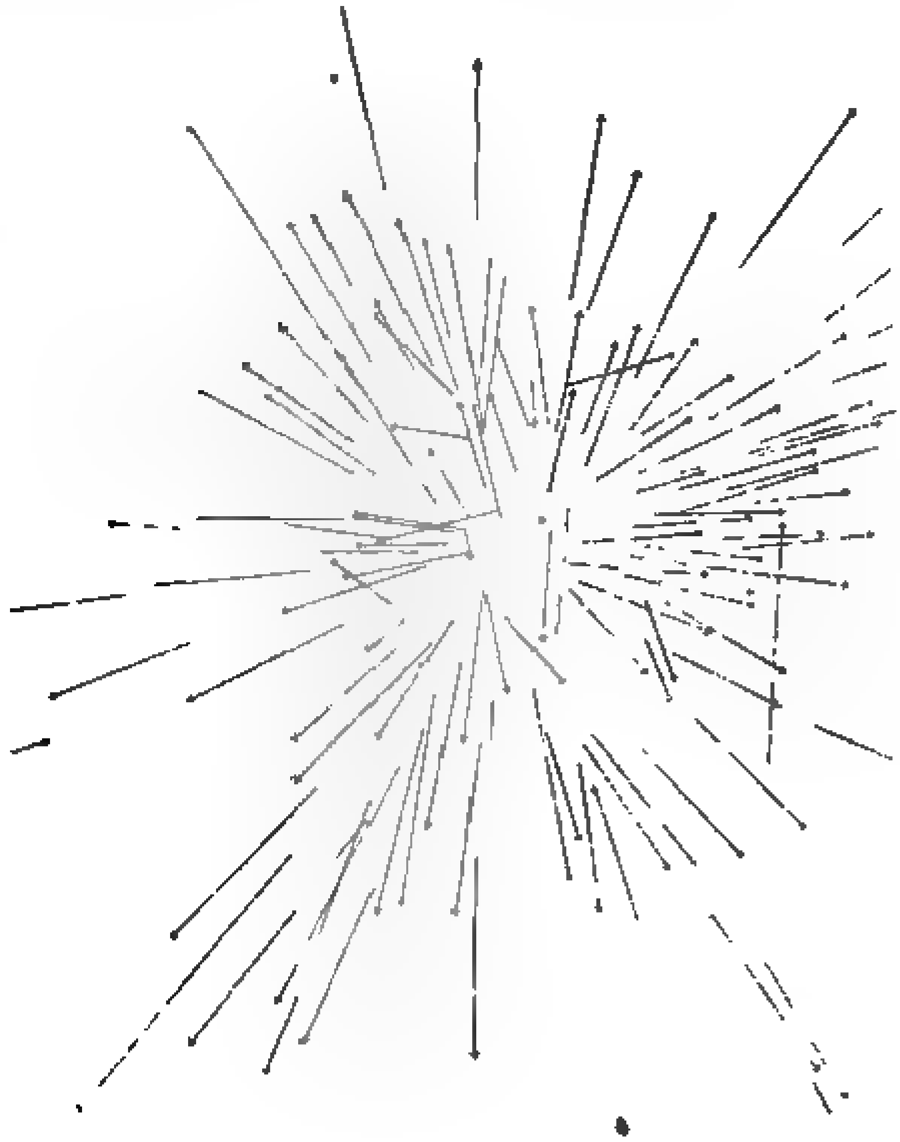


Fig. 13.—Meteors seen in Italy, Nov. 27, 1872.

was the main body of the comet it ought to be visible as it went off from us. For this, however, we must see the southern sky. He telegraphed to Mr. Pogson at Madras in India "Biela touched earth Nov. 27. Search near Theta Centauri." Mr. Pogson looked for the comet and found it. On two mornings he saw a round comet with decided nucleus, and having on the second morning a tail eight minutes long. But clouds and rain returned the next day. This is the last that has been seen of Biela's comet.

Was this Pogson comet one of the two parts of Biela seen in 1845 and 1852? This is yet an open question among astronomers. It may have been, but I think it was not. The Biela comets should have been nearly 200,000,000 miles away.

heir orbits had been computed with care. The comets, as ngle or double, had been observed for 80 years, that is 12 :volutions, and we knew well their orbits. All known dis- ırbing forces had been allowed for. It could hardly be that ıey should have gone so large a distance out of the way. It , much more probable that this was a third large fragment, ırown off centuries ago. The two observations made by Mr. 'ogson were not enough to compute an orbit from, but they o show that his comet was very near us, and were such as ne traveling in the Biela stream might give. But they also ıow that the earth did not pass through the Pogson comet entrally.

Orbit of the Biela Meteors.—In 1798, when the earth was at , and Brandes saw the fragments from Biela, the comet was C (fig. 7). In 1838 Mr. Herrick and others saw such frag- ents of the comet at N, 300,000,000 miles ahead of the main ody at A, and in 1872 we met like fragments at N, 200,000,000 iles behind the main body, which should have been at B. hus the fragments are strewn along the comet's orbit, prob- ıly in clusters, for at least 500,000,000 miles.

My story of Biela's comet and of its fragments has covered)0 years. Do we get any glimpses of its earlier life, and can e guess how it grew into its present shape? Yes, we may ake our hypothesis. But we must not forget that to tell ;hers how God must have made the world is bewitching to ıany minds, and that of the thousands of trials at world- uilding almost all have been grievous failures. With this ıution let me give you a plausible form of this early story of iela.

Once upon a time, hundreds of thousands of years ago, this omet was traveling in outer space, among the fixed stars, too ır away to be attracted by the sun. What I mean by this uter starry space may be told by the help of the pictures I ave shown you. In them the earth's distance from the sun ı 10 inches, and the comet's longest range about five feet. Ipon the scale of these figures only a few of the nearest fixed tars, perhaps two or three only, would be in the State of 'onnecticut. In this starry space the comet was traveling. Vhat had happened before I do not try to guess. How, when, y what changes, its matter came together, and had become olid, I do not know, nor whether, in fact, it had not always een solid.

In the course of time its path and the sun's path through pace lay alongside of each other, and the sun drew the comet own toward itself. If the comet had met no resistance as it ın around the sun, whether from the ether that fills space, or om the sun's atmosphere, and if it had not come near any of

the planets, it would have gone off again into outer space whence it came. Some such cause robbed it of a little of its momentum, and it could not quite rise out of the sun's controlling force, but it came around again in an elliptic orbit to remain thenceforth a member of the solar system. It may or it may not then have been a great comet, like Donati's (in 1858). It was probably a small one. It may have made its circuit of the sun in tens of years or in tens of thousands.

At some time, probably in the early historic ages, it came near the huge planet Jupiter. When it had gone out of his reach it had just momentum enough left to go around the sun in its present orbit of 6⅝ years. It went away from Jupiter an entire and single comet. As it came near the sun, his burning heat acting upon the cold rocky body of the comet cracked off and scattered in every direction small angular bits. At the same time a very thin vapor, shining by its own light, was set free. To this vapor both comet and sun had an unaccountable repulsion. It was driven off first by the comet every way. But soon that which was sent toward the sun was driven back again, and it went streaming off into space to form the comet's tail, a process ably set forth by Professor Norton.

This matter which made the tail of the comet never got back. It had, moreover, nothing whatever to do with the meteoroid stream. The meteoroids are solid fragments. To them the sun, at least, had little repulsion. The comet was so small that perhaps the force with which a boy can throw a stone would have sent the bits of stone entirely off the comet, never to come back. Those which were shot forward from the comet near P (first figure) went up along the orbit with greater velocity and rose higher from the sun than the comet did near D. Having a longer road to travel, they took a longer time to come around to P in each circuit. On the other hand, those bits which were shot backward followed the comet with less velocity and could not quite rise to D, and so having a shorter road to go over came sooner back to P, gaining on the comet at each circuit. Thus the stream grew longer slowly, and new fragments being thrown off at each circuit, the meteoroid stream grew in length to its hundreds of millions of miles. At times, the main comet has broken into two or more parts, giving us the double comets of 1845 and 1852, the Pogson comet of 1872, and the double meteor stream of November, 1872.

RT. VIII.—*Relation between Direct and Counter Electromotive Forces represented by an Hyperbola;* by H. S. CARHART.

[N the usual discussions respecting the relations between the ctromotive force (E. M. F.) of the generator, the counter E. F. resulting from the electromagnetic reactions taking place he motor, and the rate at which energy is absorbed by the er in the electrical transmission of power, it is implicitly med that E is constant. Thus the equation, representing the ision of the whole electrical energy spent in the circuit in t time into heat and mechanical work, viz:

$$CE = C^2R + W_{\prime}$$

lifferentiated so as to obtain the first differential coefficient $W_{\prime}$ with respect to C, R and E being constants. Hence $\frac{dW_{\prime}}{dC} = E - 2CR = 0$ for a maximum, the second differential coient being negative. C is therefore equal to $\frac{E}{2R}$, or the rent is reduced to half the value it would have with the tor at rest, by the reduction of the effective E. M. F. to -half.

f, however, we take the equation expressing the electrical rgy absorbed by the motor per second as the product of the nter E. M. F. and the current, we have, as is well known,

$$\frac{E_{\prime}(E-E_{\prime})}{R} = W_{\prime} \text{ or } E_{\prime}(E-E_{\prime}) = RW_{\prime}\,. \quad . \quad . \quad (1)$$

m this it appears that if R and $W_{\prime}$ are constants, $E_{\prime}(E_{\prime}-E_{\prime})$ lso a constant. But when the product of two factors is a stant, their sum is a minimum when they are equal to each er. It follows that the sum of $E_{\prime}$ and $E - E_{\prime\prime}$ or E, is a imum, when $E_{\prime} = E - E_{\prime}$, or when $E_{\prime} = \frac{1}{2}E$. By substitu- in equation (1) $E_{\prime} = \sqrt{RW_{\prime}}$.

Vith an assumed amount of work spent upon the motor per sec and a given resistance R, E has a minimum value equal to e $E_{\prime}$. This corresponds with Jacobi's law of maximum rate vorking, or greatest electrical activity and constant E. M. F. idently the conditions of greatest activity and constant E. M. of the generator are identical with those of constant energy orbed by the motor and minimum E. M. F. of the generator.

Equation (1) gives

$$E_{\prime}^2 - EE_{\prime} = -RW_{\prime} \quad . \quad . \quad . \quad . \quad (2)$$

equation of the second degree and therefore of a conic sec-

tion. On applying the proper criterion it readily appears the locus of this equation is an hyperbola. For the purpo a graphical representation of the continuous relation betwe and $E_{\prime}$, let us assume $R.W_{\prime}$ equal to 225; minimum E will equal 30 units.

Solving equation (2) for $E_{\prime}$ and substituting in the result cessive different values of E as the independent variable obtain corresponding values of $E_{\prime}$ which satisfy the equa Each assumed value of E gives two plus values of $E_{\prime}$. hyperbola I is thus plotted, making the assumed values abscissæ and the corresponding ones of $E_{\prime}$ ordinates. considered essentially positive.

By a comparison with the most general equation of a c section, the constants of this particular one may be d mined.

Thus independently of the assumed value of $RW_{\prime}$, $e^2=4$ and $e=1{\cdot}0824$, the other value of e making n imagir

Also $\cos a=\pm\frac{1}{e}$ and $a=22°\ 30'$, the minus value of the c not being admissible because then m would become nega But all values of E are positive, and hence m cannot be ative.

Since the cosine of the angle between the transverse ax an hyperbola and its asymptotes is the reciprocal of e, it fol that the asymptotes of this curve are the axis of X and diagonal OG, the angle between them being 45°. The ch ter of the curve is thus entirely determined without kno the value of $RW_{\prime}$.

Assuming now $RW_{\prime}$ equal to 225, the coördinates of focus are $m = 32{\cdot}96$ and $n = 13{\cdot}65$.

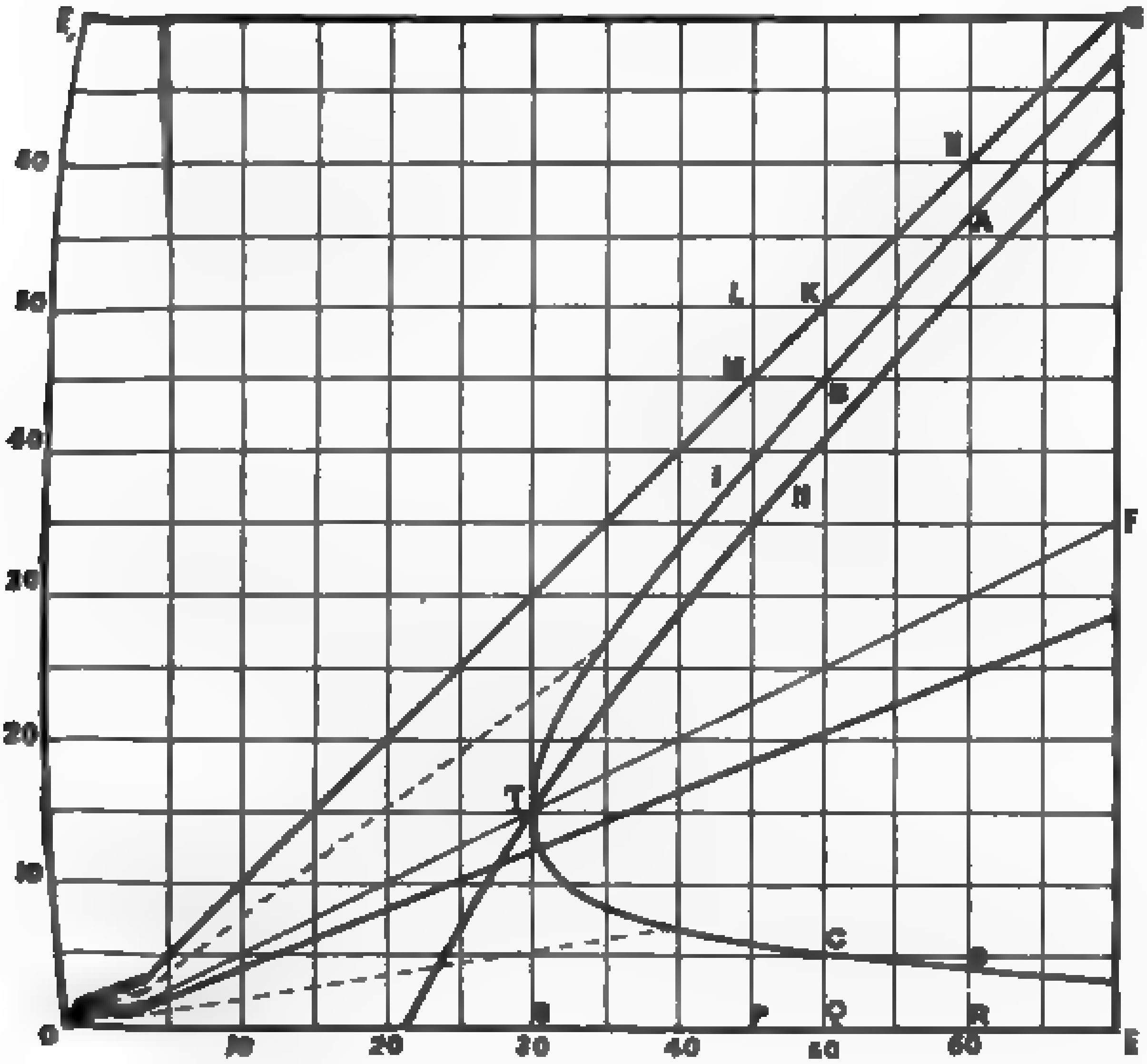
It is evident also from the properties of the hyperbola m and n in this case equal A and B respectively. The per dicular distance of the directrix from the origin is 30·45.

A number of inferences can be drawn directly from the c by inspection. It is seen that E is a minimum when it is do $E_{\prime}$. At this point the hyperbola is tangent to an ordinate; point of tangency will travel along the line OF, away from origin or toward it according as the assumed value of I increases or diminishes. OF is therefore the line of minimu and its equation is $E_{\prime}=\frac{1}{2}$ E.

The electrical efficiency at any point of the curve, being quotient of $E_{\prime}$ by E, is the tangent of the angle which a drawn from the point to the origin makes with the X- The efficiency at T is the tangent of the angle TOE, or half. The electrical efficiency increases from zero, whe is zero and E is infinite, to unity, when $E_{\prime}$ equals E and are infinite; the angle, whose tangent is the measure of the

ciency, is then the angle between the asymptotes, or 45°, and the tangent of 45° is unity. The limits of the efficiency correspond to the points where the curve touches the asymptotes.

It is also evident that near the point where E is a minimum $E_{,}$ increases most rapidly. That is, near the point where the efficiency is one-half it has its greatest increments. Beyond an electrical efficiency of about 75 per cent. the direct and counter electromotive forces increase in nearly the same ratio, and the efficiency therefore increases very slowly.



E and $E_{,}$ denote direct and counter electromotive forces; C current and R resistance in circuit connecting generator and motor; W the total electrical energy contributed by the generator, and $W_{,}$ the electrical energy absorbed by the motor in unit time; e the eccentricity; A and B the semi-axes; m and n the coördinates of the focus of the hyperbola; a the angle between the axis of X and the axis of the conic section.

The diagram shows, further, that $E_{,}$ and C pass through corresponding series of values, but in the inverse order. The current is proportional to $E - E_{,}$, the resistance being constant; and since the intercepts of a secant between an hyperbola and

its asymptotes are equal, that is, AH equals DR for instance, when the counter E. M. F. passes through the series of values represented by the ordinates DR, CQ, TS, BQ, AR in succession, the current will be proportional to AR, BQ, TS, CQ, DR in succession. With the condition that the motor absorbs a constant amount of energy per second, the current is a maximum when the counter E. M. F. and the electrical efficiency are a minimum: and it diminishes continuously as the efficiency increases.

If now the the constant chosen is not the rate at which energy is absorbed by the motor, but the electrical energy contributed by the generator per second, we then have the equation

$$CE=\frac{E(E-E_{,})}{R}=W, \text{ or } E^2-EE_{,}=W \quad . \quad (3)$$

This is again an equation of the second degree and its locus is the hyperbola II. Its axis makes an angle of 157° 30′ with the axis of X and its asymptotes are OG and the axis of Y. Its eccentricity is 2·613, the second value obtained from the equation $e^2=4\pm\sqrt{8}$, the other value being the eccentricity of hyperbola I.

In this case the two machines and the conductor joining them form a system the only condition laid down being the constancy of RW. Hence the relation between E and $E_{,}$ may be found either when the motor is driven by the current and furnishes counter E. M. F., or when it is driven by mechanical means so as to contribute to the direct E. M. F. If the motor is actuated by the current then E has its minimum value when $E_{,}=0$, or at the point where the hyperbola crosses the axis of X; but if the motor dynamo contributes E. M. F. in the same direction as that of the other machine, then E may diminish still further, even to zero in the limit. In this case RW represents still the energy furnished by the generator, but not the total electrical activity per second. The part of the hyperbola lying below the axis of X corresponds to values of E and $E_{,}$ obtained when the motor is driven mechanically so as to furnish direct E. M. F.

In the first curve any assumed value of E greater than the minimum gives rise to two values of $E_{,}$, both positive. In the equation of the second curve the substitution of a positive value of $E_{,}$ gives two values of E, one positive and the other negative, indicating another branch to the curve. This other branch represents the relation between E and $E_{,}$ when the part played by each machine is reversed, the motor becoming the generator, and the generator becoming the motor by being driven electrically.

In curve two the efficiency is measured in the same way as efore. Again it is seen to increase as the electromotive forces icrease. The current, represented by the intercepts of the rdinates between the hyperbola and its asymptote OG, dereases as the efficiency increases. The same was true in the ther case.

It remains only to point out that Jacobi's law of maximum ıte of working applies only under the condition of a constant . M. F. in the electric supply.

This will be evident upon careful inspection of the diagram. ıe energy spent upon the motor per second is represented by (E−$E_,$); the electrical energy supplied by the source per ·ond, by E (E−$E_,$).

The first expression is the product of the two parts into which ; line denoting E is divided at any point by curve I. Since r bisects the angle between the two rectangular axes, the linate of any point of this line equals the abscissa of the ints of the hyperbola through which it passes. Thus KQ ıals OQ or E, the direct E. M. F. corresponding to the points and C of the curve. Hence BK equals E−$E_,$; and the proct of BK and BQ, or the area of the rectangle BMPQ, is the ıstant RW, of the equation of this hyperbola. The area of such rectangles is the same for this curve. In a similar way ; area of KLPQ is the rate at which electrical energy is suped to the circuit; and the difference between the two rectanes, or the square KLMB, is the heat waste per second at this int of the curve.

Now while the area of the first class of rectangles is the same r all points of the curve, that of the second and of the squares minishes as $E_,$ and the efficiency increase from point to point ong the curve in the direction D, C, T, B, A.

If the same analysis is applied to curve II it will be found ıat the area of the rectangle expressing the electrical work pent upon the motor per second increases, the rectangles denong the rate at which energy is supplied by the generator ll equal RW, and the area of the square representing the 'aste in heat diminishes from point to point, as E, $E_,$ and the fficiency increase.

We may therefore distinguish three cases, R being constant each case:

rst, When E is constant.

Then $W_,$ is a maximum when $E_,$ is half E by Jacobi's law.

The electrical efficiency increases with $E_,$.

The current diminishes as $E_,$ increases.

W diminishes from a maximum to zero when the efficiency is unity.

Second, When $W_{,}$ is a constant.

Then E is a minimum when $E_{,}$ is half E.

The electrical efficiency increases with $E_{,}$.

The current diminishes as $E_{,}$ increases.

W diminishes from infinity to $W_{,}$ when the efficienc

These are the limits.

Third, When W is a constant.

Then $W_{,}$ is a maximum only when the efficiency

in which case E and $E_{,}$ are infinite.

E has a minimum value of $\sqrt{RW}$ when $E_{,}$ is zero.

(The case of the motor driven mechanically is not

The electrical efficiency increases with $E_{,}$.

The current decreases as $E_{,}$ increases.

Jacobi's law applies only to the first case. When is to be employed to run an electric motor, then E is t term to consider constant; but if it is required that furnish a definite amount of power, then the graphica tion of hyperbola I shows that E has a minimum points out some of the conditions of high efficiency.

ART. IX.—*Tendril Movements in Cucurbita maxima an* by D. P. PENHALLOW.

(Continued from page 57.)

OBSERVATIONS upon the movement of both tendri minal bud were made both day and night for an en and thus the motion of each arm, for almost its entire activity, was secured. Temperature and other mete conditions were noted at each observation, taken d night at intervals of an hour—sometimes less—and d day as often as seemed necessary from the activity thus frequently at intervals of two minutes.

Tendril No. 1.

At 9.30 in the morning of August 12th, one of th arms was selected after it had been sometime uncoile movements were noted until there was no further moti entire time over which the observations extended hours and thirty minutes. During this time, the t traversed a distance of $343 \cdot 15^{cm}$, giving an average r of $0 \cdot 54^{cm}$ per minute.

The greatest rate of movement at any one time w per minute, and occurred two and one-half hours wave of maximum temperature had passed. The most rapid motion extended from 2.30 to 4.30 P. M

following the greatest heat wave. The waves of slowest motion covered the time from 10 A. M. to 2.30 P. M., coincident with a rising temperature. The absolute minimum of motion occurred just before the maximum of temperature and was at the rate of 0·21^{cm} per minute. At 4 o'clock in the morning, a heavy rain ceased. The air was still surcharged with moisture, and the sky was entirely overcast with heavy clouds. It was while this condition lasted that the waves of slowest motion occurred, the minimum being found during the interval from 12.15 to 1 P. M. At the latter hour the clouds broke and the sun came out brightly and so continued until 6 P. M., when the sky again became overcast and rain set in at 7 o'clock. While the sun was out, the tendril was most active, absolute maximum of movement taking place in the five minutes from 3.25 to 3.30 P. M., the whole distance traveled in that time being 16·30^{cm}.

The first direction of movement was to the right. This, however, was obviously purely accidental, since the direction first recorded must depend upon the time of first observation, dextrorse alternating with sinistrorse action during the whole movement of the tendril. The entire motion to the right amounted to 190·8^{cm}; that to the left reached a total of 152·35^{cm}; the ratio of the one to the other thus being as 1 : 0·79.

Tendril No. 2.

The second tendril was selected on the 13th of August, at 8 o'clock A. M. It was a shorter arm than No. 1, and rather nearer the end of its activity. The time of movement was six hours and fifteen minutes, and the entire distance traveled was 136·00^{cm}, thus giving an average rate per minute of 0·36^{cm}.

The absolute maximum of movement was 1·76^{cm} per minute and occurred from 10.15 to 10.20 A. M., forty-five minutes before the maximum temperature for the day was reached. The waves of most rapid movement covered the time between 8 and 10.50 A. M., coincident with increasing temperature. The waves of least motion occurred between 10.50 A. M. and 2 P. M., during a slight depression of temperature. The absolute minimum was reached between 10.50 and 12.15 M., and amounted to 0·179^{cm}. It directly succeeded the maximum of temperature. During the entire time of observation, the weather was very pleasant, though somewhat cloudy. At twelve o'clock, the leaves began to droop from the effects of excessive transpiration and heat. This continued until after the close of observation. It was during this time of depressed activity and reduced tension, that the minimum of motion occurred. During the entire morning, all the leaves and flowers showed great vigor, and it was while in this condition that most active move-

ment took place. The first motion observed was to the left, and was not replaced by dextrorse movement for some time. The entire sinistrorse action was $94{\cdot}20^{cm}$. The dextrorse was $41{\cdot}80^{cm}$, a ratio of the latter to the former of 1 : 2·25.

Tendril No. 3.

The time of observation was ten hours and thirty minutes, commencing at ten o'clock A. M., on August 13th. The total length of movement was $329{\cdot}30^{cm}$, and the average rate per minute was $0{\cdot}52^{cm}$. The times of greatest movement were from 1 to 3.15 P. M., and from 5.15 to 8 P. M.; the former occurring at the time of the wave of maximum temperature, the latter during a diminishing temperature. The absolute maximum of motion was $3{\cdot}55^{cm}$ per minute, and occurred during the two minutes from 1.50 to 1.52 P. M., succeeding the maximum temperature by two hours and fifty minutes, at a time when there was a slight temporary depression of temperature. The distance traveled in this short interval was $7{\cdot}10^{cm}$.

The time of least motion was from 12.15 to 1 P. M., during the time of greatest heat, and again from 3.15 to 5.15 P. M., following a diminution of temperature. The absolute minimum of motion was $0{\cdot}013^{cm}$ per minute, and occurred from 12.15 to 1 P. M. on a decreasing temperature, and following the maximum temperature by one hour and fifteen minutes. During this time, the weather was pleasant but somewhat cloudy. From 11 A. M. until 5 P. M. all the leaves and flowers were drooping, indicating a weak vital action through excessive transpiration.

The first movement recorded was to the right, soon succeeded by a reverse to the left. The entire amount of the former was $261{\cdot}50^{cm}$; of the latter, $67{\cdot}80^{cm}$; the ratio of dextrorse* to sinistrorse being as 1 : 0·25.

Tendril No. 4.

This tendril was taken August 14th at 8 o'clock A. M., but so late in its growth that only twelve movements were obtained. These covered seven hours and fifty minutes in all. The whole length of movement was $66{\cdot}20^{cm}$, and the average rate per minute was $0{\cdot}14^{cm}$. At no time was there any exhibition of very great activity, the tendril appearing to move as if in the last stages of growth, which it really was. The most rapid movement appeared at 9.41 to 9.50 A. M., the extremity passing through 7.70^{cm} in nine minutes, an average rate of $0{\cdot}85^{cm}$ per minute. This coincided with the highest temperature and was just prior to a fall of two degrees. The time of

* Dextrorse and sinistrorse are applied upon the supposition that we stand at the base and look to the tip of the tendril.

t activity was from 9.50 A. M. to 3.50 P. M. The absolute imum of motion was from 2.10 to 3.50 P. M., amounting to 31^{cm} per minute. It occurred on a decreasing tempera- e, five hours and fifty minutes after the maximum tempera- e had passed. During this time the sun was shining brightly, ugh its effect was somewhat modified by numerous clouds. m twelve o'clock to the close of observations, during the e of least activity, the leaves and flowers were all depressed n the effects of the heat. The movements as first recorded e to the left, but after two courses changed to the right. total dextrorse movement was 18·4^{cm}; the sinistrorse 0^{cm}; thus giving a ratio of 1 : 2·6.

Tendril No. 5.

o. 5a.—This tendril was selected August 13th at 4 P. M., as n as it had straightened out from the bud, and very nearly first nutations were obtained. Observations were inter- ted after a few hours and not resumed until the next morn- . The entire length of movement was 107·60^{cm}, occupy- four hours and thirty minutes, thus giving 0·39^{cm} as the rage rate per minute. The greatest movement was at the of 1·44^{cm} per minute and occurred from 4 to 4.05 P. M., the very commencement of action and observation. The e of greatest movements occurred from 4 to 4.35 P. M., and in from 5.30 to 7 P. M., coincident with decreasing tempera- e.

east activity was noticed at 7.55 to 8.10, when the tip moved the rate of 0·13^{cm} per minute. This occurred at the time lowest observed temperature, the thermometer standing a 21° The time of best movements was found to extend from 4.35 5.30, and again from 7 to 8.50 P. M., when the observations sed.

At the commencement of observations, the sun was shining ghtly and its effect was sufficiently strong to cause a de- ssion of all the leaves and flowers. Shortly after observa- s ceased, the sky became cloudy, and at nine o'clock there a heavy shower, which revived the plant and brought all parts once more into active condition. The first recorded vement was to the left, action in this direction predominat- during the time of observation. The entire movement to right was 18·80^{cm}; that to the left was 88·80^{cm}, giving a o of 1 : 4·72.

o. 5b–c.—This tendril was the same as 5*a*, observations n which were interrupted at 8.30 P. M., August 13th, and med the next morning at 8 o'clock, continuing through the and 15th. During the night the arm was quite active, in the morning showed no tendency whatever to discon-

tinue its nutations. From the time indicated, observations were continued for twenty-three consecutive hours. The entire distance traveled during that time was $511 \cdot 70^{cm}$, thus giving an average rate of $0 \cdot 37^{cm}$ each minute. The number *5b–c* was given to indicate a change of recording papers. This occurred at 6.20 P. M., at a time when the tendril tip had drooped to the ground and did not resume its movement until 8.35 P. M., when the nutations continued as before.

The time of most rapid movement was during the two minutes from 4.55 to 4.57 P. M., on a descending temperature, and five hours after the maximum wave had passed. The total rate of movement was $4 \cdot 55^{cm}$ per minute. The times of most rapid movements occurred from 8 to 10.20 A. M.; 1.30 to 2 P. M.; 4 to 5 P. M., and 10.53 to 11.05 P. M.; the maximum of these being from 4 to 5 P. M. The absolute minimum of motion occurred from 4 to 5.04 A. M., when the tip traveled at the rate of $0 \cdot 043^{cm}$ per minute, this being at a time of low temperature. The times of least movement were from 10.20 A. M. to 1.30 P. M.; 2 to 4 P. M; 5.30 to 10 P. M. and from 11.05 during the remainder of the night and until the end of the experiment at seven o'clock in the morning. There appears in these observations a very sharp division at 5.30 P. M., between the waves of more rapid daily movement and the waves of slower motion during the night.

The experiment commenced with very pleasant weather and all parts of the plant in vigorous condition, the leaves being erect and the flowers open. From 12 M. to 4 P. M. the leaves were drooping and the activity of the plant small. This, with the exception of one-half hour from 1.30 to 2 P. M., was a time of slow movement. At 4 o'clock P. M., the leaves began to resume their normal, fresh appearance, and so continued until the close of observations. Towards morning a very heavy fog gathered and reached its maximum at four o'clock, the time when the absolute minimum of motion occurred.

Sinistrorse movement was first noticed. In the movements of this tendril, there appeared a greater equality between right and left motion than was noticed in any of those previously experimented upon. The entire dextrorse movement was $282 \cdot 10^{cm}$; the sinistrorse $229 \cdot 60^{cm}$, a ratio of $1 : 0 \cdot 81$.

Tendril No. 6a–b.

As in the preceding case, the letters *a–b* designate a change of paper. This occurred at 7 o'clock P. M., while the tendril was quite active, but it in no way disturbed the movement. The filament was selected August 14th at 1.15 P. M., when a short time from the bud, and observations were continued consecutively for eighteen hours and fifteen minutes. The dis-

nce traveled by the tip during this time was 327·80^{cm}, an rerage of 0·29^{cm} per minute.

Most rapid movement occurred from 6.50 to 6.52 P. M., at e rate of 6·50^{cm} per minute. This was on a decreasing temerature, and six hours and fifty minutes after the wave of aximum temperature had passed. The time of greatest ovement was from 3.50 to 7.10 P. M., on a decreasing temerature. The least motion was 0·047^{cm} per minute, and ocrred at 11.25 A. M. to 12.35 P. M., on a decreasing temperature, d within three degrees of the lowest phase of the thermal ave. The times of least movements were from 1.15 to 3.00 M., and from 7 P. M. to the close of observations. As in ndril 5 *b c*, there was in this a noticeable distinction between e waves of more rapid diurnal motion, and those of slower cturnal movement. The time of division was 7 P. M.

The tendril commenced action with a dextrorse movement, d here was noticed a greater equality between right and left an in even the previous case. The whole movement to the ght was 166·10^{cm}; that to the left 161·70^{cm}, the ratio, therere, being as 1 : 0·97.

At the commencement of observations, the sun was bright d the temperature high. The vitality of the plant was much epressed and the action slow, all the leaves drooping from xcessive transpiration. This continued until 4 P. M., during hich time there were slow waves. At 4 o'clock the plant evived, the leaves became erect and the normal condition and ctivity were once more restored. From that time until sunset, he waves of greatest movement occurred. The sky was clear ntil after midnight, but slow waves continued throughout the emainder of the night, with a slight acceleration just after unrise.

Tendril No. 7.

No. 7a.—Observations commenced August 16th, at 9 o'clock . M., and were continued for ten consecutive hours. The otal distance over which the tip moved during this time was 27·10^{cm}, or at the rate of 0·38^{cm} per minute.

The time of most rapid movement was from 5 to 5.20 P. M., hen the tip moved 0·92^{cm} per minute. This occurred just t the outset of a rapid decline in temperature, and six hours fter the maximum of temperature had passed. The time of reatest movements was from 3.15 P. M. to the close of obseration at 7 o'clock, and was coincident with a rapid decline in mperature. The time of least movement was from 1.42 to .25 P. M., the tip moving at the rate of 0·053^{cm} per minute. his was during high temperature, but one hour and forty-two inutes after the maximum had passed. The waves of least otion were found from 9 A. M. until 3.15 P. M., with a marked

retardation toward the latter hour. These waves were coincident with the greatest heat wave, the greatest retardation of motion occurring after the maximum of heat had passed.

The experiment commenced with the sky clear and the plant in an active condition. As the heat increased, however, its effects upon the plant were noticed, and at 12 o'clock, with the thermometer at 34·4° C., the leaves drooped and the whole plant was in a very flaccid condition. During this time the waves of slowest motion occurred. This condition continued until, with considerable fall in temperature during the afternoon, the normal tension and activity of the plant were restored, when the waves of greatest movement were noticed. The entire dextrorse movement of the tendril was 92·90^{cm}, the sinistrorse 134·20^{cm}, and the ratio was, therefore, as 1 : 1.44.

No. 7b.—This was the same as the preceding, observations upon which were discontinued during the night, but resumed on the morning of the 17th at 8 A. M., and carried over a period of seven hours and fifty minutes. The entire movement during this time was 94·40^{cm}, giving an average rate per minute of 0·205^{cm}. Most rapid movement was at the rate of 0·555^{cm} per minute, and occurred from 8 to 8.15 A. M., at the very commencement of observations and on a rising temp·rature, six hours before the maximum was reached. The waves of most rapid motion were found from 8 to 11.30 A. M. Least movement took place at 1.30 to 2 P. M., at the rate of 0·08^{cm} per minute. This was just at the time of maximum temperature. The waves of least motion were found from 11.30 A. M. to the close of observations at 3.40 P. M., coincident with a rising and maximum temperature.

Observations commenced with moderate temperature, clear sky and an active condition of the plant, continuing thus during the time of greatest movement until, at 11 o'clock, the leaves became depressed from the effects of heat, and from 11.30 on, the waves of slow motion were found. At 12 M. the sky was overcast and the air loaded with moisture. At 1 P. M. the leaves were restored to their normal condition and erect position. At the same hour rain commenced and continued during the remainder of the experiment.

The total movement to the right was 25·10^{cm}; to the left 69·30^{cm}, and the ratio was, therefore, as 1 to 2·76.

Tendril No. 8.

No. 8a.—This filament was selected August 16th at 9 A. M. The time of observation covered a period of nine hours and fifty minutes, or until 6.50 P. M. The entire movement during this time was 314·50^{cm}, giving an average rate per minute of 0·516^{cm}. The time of greatest movement was from 3 to 3.15

and the rate per minute $1 \cdot 20^{cm}$. This was on a de-
ng temperature, four hours and fifteen minutes after the
mum. The waves of greatest movement were found from
I. until the end of observations, and during a diminishing
erature. The time of least movement was from 11.25 to
A. M., and the rate per minute $0 \cdot 166^{cm}$. This was at
ime of maximum temperature. The waves of slowest
ment extended from 9 A. M. until 2 P. M., with slight
eration of movement toward the latter hour.
servations commenced with a bright sun and the plant in
e condition. At 12 o'clock the leaves drooped, with the
ometer at 34·4° C., and this condition continued until
in the afternoon, when they revived, with decrease of
It was during the passive condition of the plant that the
st movements were observed, the more rapid waves occur-
with renewed vigor and active condition. The entire
orse movement was $143 \cdot 10^{cm}$; the sinistrorse $161 \cdot 40^{cm}$,
he ratio was, therefore, as 1 : 1·12.
. 8*b*.—Observations were resumed at 8 o'clock A. M. of
ist 17th, and were extended over seven hours and forty-
minutes. The distançe which the tip traveled during this
was $225 \cdot 00^{cm}$, or at the rate of $0 \cdot 483^{cm}$ per minute. The
est movement was at the rate of $2 \cdot 60^{cm}$ per minute, occur-
from 3.40 to 3.45 P. M., at the very close of observations,
one hour and forty-five minutes after the maximum of
erature. The waves of most rapid movement were from
to 3.45 P. M.
ist movement occurred at 10.15 to 10.30 A. M., at the rate
10^{cm} per minute. The waves of least motion extended
8 A. M. until 3.15 P. M., coincident with a rising and
mum temperature. Observations commenced with a
t sun and the plant active. At 11 o'clock A. M., just
minutes after the minimum of motion occurred, the
s were all drooping as a result of excessive transpiration.
o'clock P. M., it was raining, and the normal activity of
lant was restored. This continued until the close of ob-
tions. The entire dextrorse action was $103 \cdot 50^{cm}$; the
rorse $121 \cdot 50^{cm}$, and the ratio therefore as 1: 1·17.
. 8*c*.—Observations upon No. 8*ab* were resumed on the
of August at 5 o'clock P. M. and extended over fifteen
. Apparently on account of its age, and the time of
vation, the entire movements were slow, amounting in the
n hours to only $159 \cdot 00^{cm}$, giving an average rate per min-
of $0 \cdot 176^{cm}$. The greatest movement was at 7.12 to 7.28
at the rate of $0 \cdot 65^{cm}$ per minute. The waves of most
movement were from 5 to 7.30 P. M., with a slight accele-
n in the morning. Least movement was found at 2.30 to

3 P. M., at the rate per minute of 0·023^{cm}, occurring at the time of minimum temperature. The extreme variation of temperature during the hours of observation, was only 2° C. A light rain fell during the greater part of the time, and heavy clouds obscured the sky the remainder. The movement to the right was 117.60^{cm}; to the left 41·40^{cm}, and the ratio therefore, as 1 : 0·35.

Tendril No. 9.

The last tendril experimented with was selected August 17th at 6 o'clock P. M. It was in the last stages of movement, and exhibited the least horizontal movements of any upon which observations were taken. The whole length of movement was 191·30^{cm}; the time sixteen hours and forty minutes, and the consequent average rate per minute was 0·191^{cm}.

The greatest movement was from 7 to 7.06 A. M., at the rate of 2·17^{cm} per minute. This occurred in a slightly increasing temperature. The waves of most rapid movement were from 5 to 9 A. M. The least movement occurred from 9.30 to 10.00 P. M., at the average rate of 0·02^{cm} per minute. The waves of slowest movement were found from 6 P. M. until 5 A. M.

The temperature varied only three degrees during the entire time of observation. From the commencement until 10 o'clock P. M., light rain fell and the sky was entirely overcast until the close of observations. At 5 A. M., there was a cool east wind with a very large amount of moisture in the air, and the plant was apparently in a very active condition. At the close of observation, heavy rain commenced to fall. The total dextrorse movement was 160·40^{cm}; the sinistrorse 30·9^{cm}; and the ratio as 1 : 0·181.

Terminal Bud.

For experiment, there was selected a good terminal bud upon the extremity of a vigorous vine growing directly from west to east. The observed movements were chiefly in vertical direction, those in a horizontal plane being, apparently, not so conspicuous. The total movement was 96·90^{cm} at the average rate of 0·065^{cm} per minute, the observations extending over fifteen hours and twenty-eight minutes. As might be expected, this movement was much slower than that of the tendrils, but at the same time, sufficiently rapid and continuous in a given direction, to make the observations very easy. In this circumnutation, geotropism and heliotropism exert an important influence upon the figure described by the tip as the result of growth. The end of the vine is constantly turned upward, and during a certain time becomes more and more elevated, finally falling back towards the ground. This is repeated continually during the entire growth of the vine, the change usually taking place once each day.

The greatest rate of movement was found to be $0{\cdot}42^{cm}$ per minute and occurred from 10.10 to 10.40 A. M. on a rising temperature. The least movement was from 11.30 to 12 M., at the rate of $0{\cdot}013^{cm}$ per minute.

During the time of observation, the temperature was quite uniform, varying only three degrees. The sky was overcast during the night and the air was loaded with moisture. At 5 A. M. there was a cold east wind, but this did not seem to interfere with the activity of the plant. The closing observations were taken in a hard rain, which commenced at ten o'clock. The entire dextrorse movement was $60{\cdot}10^{cm}$; the sinistrorse 36·80, and the ratio as 1 : 0·61. The whole range of vertical movement in which the effect of geotropism was very evident, was $17{\cdot}60^{cm}$; negative heliotropism (?) $16{\cdot}90^{cm}$; positive heliotropism (?) $10{\cdot}30^{cm}$.

Collateral to the observations concerning movements, it was deemed wise to collect all other facts which, through any explanation of the general phenomenon of growth they might afford, would throw light upon the special question under consideration. It was with this view that the following facts concerning growth in both vine and fruit were collected.

Growth of the vine.

To determine the hourly growth of the vine, a board, suitably marked off into a scale of inches and tenths, was placed in a vertical position at one side of the growing extremity and parallel with it. The scale was placed at one side rather than beneath in order to avoid inaccuracy which might arise through the vertical movement of the terminal bud, which would of course, at times, bring it some distance from the scale. Readings were taken every hour. Observations were continued for 158 hours, almost consecutively. The entire growth of the vine during that time was $89{\cdot}40^{cm}$, giving an average hourly growth of $0{\cdot}566^{cm}$. The most rapid rate of growth was $1{\cdot}015^{cm}$ per hour. This rate was reached eight times out of the 158 and, with one exception, occurred at noon, between the hours of 12 M. and 2 P. M. This rate was also obtained under the influence of high temperature.

The slowest rate of hourly growth was $00{\cdot}00^{cm}$. This occurred only once, at 8 o'clock P. M., and was due to no apparent cause. Minimum movements of $0{\cdot}253^{cm}$ frequently occurred The waves of least movement were obtained at or soon after midnight, consequently at a time of low temperature.

The entire growth of the vine during the night was $34{\cdot}287^{cm}$.* The entire growth during the day was $44{\cdot}447^{cm}$, and the ratio

* All the observations are not included here, as some must of necessity be left out to equalize hours of day and night.

was thus as 1 : 1·29. The hours of night were reckoned 1 7 P. M. to 7 A. M., consequently those of day from 7 A. M 7 P. M. The average rate of growth for the night was fc to be 0·49^{cm} per hour, that for the day 0·633^{cm}, or as 1 : 1·2

The hourly variations were much more regular when temperature was low, or, under a high temperature when, ing to the moisture in the air, transpiration was not exces and the normal tension of the tissues was maintained. Wl however, under conditions of high temperature and dry at sphere, transpiration was great and all the leaves, flowers terminal bud drooped in consequence of the resulting rel of tension, then the variations became more irregular. find then, so far as this goes, that while growth is contin through the night, it is much greater during the day; that higher the temperature the more rapid the growth; that ex sive transpiration interferes with regularity in growth and e retards it.

Growth of the Squash.

To determine the rate of growth in the squash, and the m ifying conditions, care was taken to select a young fruit with blemish, and to preserve the vine upon which it grew fi injury. One of Fairbanks' platform scales was drawn clos the vine and securely fixed in position. Upon it was t placed a wooden cradle adapted to the form of the squ The latter was allowed to lie upon a layer of hay to prese it from injury. The vine was carefully drawn up and allo to pass by one end of the cradle. The whole arrangement carefully balanced before and after placing the squash, and latter was found to weigh just 61 pounds, at the beginnin the experiment. The weight was taken every day at o'clock P. M. The following table will show the results.

Growth of the Squash.

Date.	Mean temp.	Total weight.	Daily inc
Aug. 9,	24·0° C.	61	0·0
10,	25·1	64	3·0
11,	23·1	67	3·0
12,	23·9	72·5	5·5
13,	23·9	75·5	3·0
14,	24·9	77·5	2·0
15,	25·9	80·0	2·5
16,	24·2	83·0	3·0
17,	21·7	86·0	3·0
18,	19·3	88·5	2·5
Totals,	235·9	755·0	27·5
Means,	23·59° C.	75·5	3·05

'rom this it will be seen that the entire gain in weight, ·ing the nine days of experiment, was 27·5 pounds, or a daily rage of 3·05 pounds, the greatest gain for any day, occur- g August 11th and 12th, and amounting to 5·5 pounds for the ·nty-four hours. During this time the sky was obscured by her heavy clouds, and showers were of frequent occurrence. e temperature was moderately high, the average for the enty-four hours being 22·6° C.

The least gain was noticed August 13th and 14th, and ounted to 2·0 pounds. During the hours of day, the trans- ·ation from the plant was excessive, and all the leaves, buds d flowers were drooping. During the night, there was a ;ht shower. The temperature was quite high, averaging ° C. for the twenty-four hours. About the first of September, ıen the squash was taken from the scales, it weighed 96 ·unds.

General Summary.

Average rate of movement. It is tolerably safe to assume that, ›m an aggregate of 436 distinct and complete observations ›on the motion of the tendrils under all conditions of temper- ure, sun and humidity, some figures can be obtained which ll represent pretty nearly, the true normal rate of movement, der all the conditions to which the plant is ordinarily sub- :ted. This we find to be 0·351^{cm} per minute.

Maximum rate of movement. By reference to the following ›le, it will be possible to trace the relation which movements greater and less rapidity bear to the temperatures for corres- ıding periods, and thus determine the specific influence of ;her or lower temperature in promoting activity.

ztion of Rate of Movement to Temperature. Degrees C. Distances in centimeters.

	1	2	3	4	5*a*	5*bc*	6*a-b*	7*a*	7*b*	8*a*	8*b*	8*c*	9	Means.
te ɜ.	0·54	0·36	0·52	0·14	0·39	0·37	0·29	0·38	0·205	0·516	0·483	0·176	0·191	0·351
of ··	2·06	1·76	3·55	0·85	1·44	4·55	6·50	0·92	0·555	1·20	2·60	0·65	2·17	2·216
x. ...	28·3	26·1	27·8	35·5	27·2	30·9	24·4	29·0	20·0	31·7	22·2	20·5	21·1	26·5
te nt.	0·21	0·18	·013	·031	0·13	·043	·047	·053	0·08	0·166	0·10	0·023	0·02	0·84
in. ...	31·1	31·7	29·5	32·2	21·7	16·7	21·1	31·1	22·8	34·0	24·0	19·5	20·0	25·8

We find that of the thirteen sets of observations here given, ly four show waves of rapid movement during the morning, ese occurring between the hours of 7.00 and 10.20, and in › case,—unless we make exceptions in favor of No. 9—repre- nting the absolute maximum of movement for the entire life the tendril. The remaining nine show the waves to occur in

the afternoon from 1.50 to 7.12 o'clock. If we now select th figures under 1, 3, 5 *b–c*, 6 *a–b*, 8 *b*, and 9,* representing t true maximum rate of motion in those tendrils for the enti period of their activity, we will find that only one occurr in the morning, all the others taking place in the afternoon b tween the hours of 1.50 and 6.50.

Selecting an equal number of hours of day and night, maki the hours of division 7 A. M. and 7 P. M., we find that we obta a total length of diurnal movement of 1359·90^{cm}; and of no turnal movement of 536·90^{cm}, thus making the latter in t ratio of 1 : 2·53 to the former, a difference which clearly indicat that temperature exerts an influence far outweighing any retar ing effect upon growth which direct and bright sunlight ma have.

This naturally brings up a question relative to the temper ture at the time these figures were taken. The six figur already selected as representing the maximum movements, we found while the temperature ranged from 21·1° to 30·9° C. C these, the highest, viz: 6·5, 4·55 and 3·55^{cm} were found whe the temperature ranged from 24·4° C. to 30·9° C.; the other thr giving us 2·17, 2·6 and 2·06^{cm}, were obtained between 21·1° an 28·3° C. We thus find that the more active of these wav were formed under the influence of a temperature 3·8° C. high than that under which the less active were produced. We als observe that while the more rapid movements are propagat under medium temperature, the slower movements are deve oped under the *extremes* of temperature, some higher, so lower. And yet again, that in the *means* of all the values each kind, the more rapid movements are developed under somewhat higher temperature than the slow movements, th indicating that while excess in either direction is detriment higher temperatures are best adapted to the most rapid grow so long as they fall within certain limits.

Pursuing this line of thought yet a little further, and takin the highest rate of each tendril movement—including, ther fore, the six first considered—we find them obtained under a average temperature of 27·2° C.: while those waves of rap movement belonging to the same tendril, but of less amplitud were propagated under an average temperature of 24·8° C. O the thirteen maxima of movement obtained, one was found t be coincident with the absolute maximum of temperatur This, however, was a movement at the low rate of 0·85^{cm} pe minute. Three were found to occur on an increasing tempera ture, usually several hours before the maximum was reached

* The remaining are not taken for the obvious reason that, as the tendrils t which they belong were in the last stage of movement, they do not represent th point now under consideration.

d nine were found to occur on a descending temperature, from o to six hours after the maximum for the day had passed.

Passing to the conditions of humidity, we find that the maximum movement of tendrils 1, 8*b*, 8*c*, and 9, were reached under nditions of great humidity, of all the remainder, when the y was clear and the sun bright. The rates of movement, in e four tendrils first mentioned, were respectively 2·06, 0·65, 2·6 id 2·17^{cm}, and were obtained when, owing to the humidity of ie air, transpiration was not very active. Tendrils 2, 3, 4, 5*a*, *ab*, and 8*a*, gave respectively 1·76, 3·55, 0·85, 1·44, 0·92, 0·555, nd 1·2^{cm}, as their maxima of motion. These values were obined while transpiration was excessive, its effect upon the lant being so great, that all the leaves and terminal buds were lrooping. Tendrils 5*bc*, and 6*ab*, in which the highest maxima rere reached, gave respectively 4·55 and 6·50^{cm}, but these alues were reached under conditions of active, though not xcessive transpiration, clear sky and bright sun, while the vhole plant was in a normally active condition, as shown by he erect leaves and fine healthy color of all parts. The mean ates of movement under the conditions first discussed, show n average of 1·43^{cm}, under conditions of favorable humidity, nd 0·707^{cm}, when the air was unfavorably dry, showing that due amount of moisture in the air is more favorable to growth han its absence, in the ratio of 1 : 0·494.

Minimum rate of movement.—Of the thirteen minimum movements recorded, we find that five occurred between sunset and idnight, two between midnight and sunrise, three between 10 . M. and 1 P. M., and three between 1 P. M. and 4 P. M. We urther find that four occurred during a minimum temperature; our just before the maximum; two just after and three at the ery time of maximum temperature. As in our previous divion, taking the figures obtained for 6*ab*, 3, 5*bc*, 8*c*, and 9 as repesenting the true minima for the entire movement of each tenril, we find the average temperature at which these movements ccurred to have been 22·9° C., while the average temperature or the whole thirteen was found to be 25·8° C. The remaining even movements of greater rapidity were found under the inuence of an average temperature of 28·2° C. The following ible will show the relation between temperature and rate of novement as just explained:

	No. of movement.	Mean temp.
Maximum movements	13	26·5° C.
Minimum "	13	25·8
Max. movements, (*a*) rapid........	6	27·2
" " (*b*) slow	7	24·8
Min. " (*a*) slow	6	22·9
" " (*b*) rapid.......	7	28·2

With reference to conditions of humidity, it is found th tendrils 6*ab* and 1 gave their minima of movement during plea ant weather, while the plant was apparently in an active co dition. The rates per minute were, 0·047, and 0·21^{cm} respec ively. Tendril 7*b*, 9, 5*bc*, and 3 gave 0·08, 0·02, 0·043, ar 0·018^{cm} respectively during a time of great moisture, and eve rain. 8*c* gave 0·025^{cm} during the time of a heavy fog and col east wind. The remainder, 4, 7*a*, 2, 8*b*, 8*b*, and 5*a* gave, re spectively, 0·031, 0·053, 0·18, 0·10, 0·166, and 0·13^{cm}, at time when transpiration was excessive, as shown by the droopin leaves and terminals, and always during a very bright sun.

Dextrorse and Sinistrorse movements.—The circumnutation o the tendril tip may commence in a direction with the sun or the reverse. Movement in either direction is by no means con tinued during the entire period of activity. Motion in one direction may soon be succeeded by movement in the opposite direction, one alternating with the other constantly. The dextrorse motion for all the observations taken aggregated 1622·10^{cm}. The sinistrorse amounted to 1400·95^{cm}; and the ratio of one to the other was, therefore, as 1 : 0·86. We see in this a very striking approach to equality in the two move ments.

Terminal Bud.

In the terminal bud we have to deal with a movement en tirely independent of the irritation of contact, but accompany ing a rapidly elongating axis which develops leaves and flow ers, as well as tendrils, first upon one side and then upon the other at alternating nodes.

The greatest movement occurred just before noon, but under conditions of great humidity. The least movement took place at night, also under conditions of great humidity. In either case there was nothing to indicate other than a normal condi tion of the plant. As in the tendril, we here notice a move ment to the right and left, the latter being exceeded by the former by 23·30^{cm}. There is in this a very evident tendency to excess of dextrorse movement, but it is a fair question, to be decided only by more extended observations, if there is not o should not be as great equality here as in the movement of th tendril. In the growth of the vine, as well as of the squash we have in the results obtained still further proof of the influ ence of meteorological conditions, as already shown.

[To be continued.]

ART. X.—*A Theorem of Maximum Dissipativity*; by GEORGE F. BECKER.

THE proposition which I desire to prove in the following pages is, in general terms, that in all moving systems there is a constant tendency to motions of shorter period, and that, if there is a sufficient difference between the periods compared, this tendency is always a maximum, so that all natural phenomena occur in such a way as to convert the greatest possible quantity of the energy of sensible motion into heat, or the greatest possible quantity of heat into light, etc., in a given time, provided that the interval of time considered exceeds a certain fraction of the period of the most rapidly moving particles of the system.

The simplest case of motion which can be selected for examination is that of a particle describing a path which returns upon itself. In any actual system, such a movement must be a "stable"* one. In a very important class of such movements, there is a position of closest approach to a fixed center and a position of greatest departure from it corresponding to the perihelion and aphelion of planetary motion, and in such cases the symmetry with reference to an axis shows that the "action" between these points must be the same in either direction. The nature of these cases indicates the investigation of half the action for an entire recurrent path.

If an actual, recurrent, stable path is compared with that which would result from an infinitesimal conservative disturbance of the same movement, it appears that the distance between the points of intersection is infinite compared with the perpendicular distance which separates the paths at any intermediate position, and at such a position the paths are infinitely nearly parallel. It is easy to show that lines perpendicular to the two paths intercept arcs on which the action is equal. If ρ is the radius of curvature at any point on one of the curves, $d\vartheta$ the angle which tangents taken at an interval of time dt make with one another, ds the arc described in this time, and if the subscript numeral $_1$ indicates the corresponding quantities for the other path,

$$\rho^2 d\vartheta = \rho_1^2 d\vartheta + \rho_1 d\vartheta \delta\rho;$$

or the curves being parallel have the same center of curvature.

* The motion of a system is stable if after any infinitely small disturbance unaccompanied by a change of total energy, it returns to some configuration belonging to the undisturbed path after a finite time and without more than an infinitesimal digression.

The last term in this equation is infinitesimal compared t the other terms and may be neglected. Hence

$$\frac{\rho d\vartheta}{\rho_1 d\vartheta} = \frac{ds}{ds_1} = \frac{\rho_1}{\rho}.$$

Let x and x_1 be arcs of the curves on which the action is same, so that $x\nu = x_1\nu_1$. Then since in general $\nu_1 dt = ds_1$ and $= ds$, the velocity being represented by ν,

$$\frac{x_1}{x} = \frac{\nu}{\nu_1} = \frac{ds}{ds_1} = \frac{\rho_1}{\rho}.$$

That is to say, the radii of curvature at the extremities of arc ds, or, more generally, perpendiculars to the two curves the extremities of this arc, intercept arcs on the two curves which the action is the same. It evidently follows that a two lines perpendicular to the two curves intercept arcs which the action is the same. A more general proposition e bracing this is one of the immediate deductions from Hamilto principle of varying action.*

The action on any natural path is a minimum provided tl the path is sufficiently short, but it is clear, from the last pa graph, that perpendiculars to the undisturbed path and the d turbed path at their points of intersection cut both paths, and tl the action is consequently the same on each between the sai initial and final positions. It can, therefore, be a true minimu on neither. The action, consequently, cannot be a minimu for a distance greater than that between these points of int section. These points are called conjugate kinetic foci Messrs. Thomson and Tait, who give propositions embraci those just stated, but reached by a different method; and w also show that while the action from a given configuration to the first kinetic focus is always a minimum, it may cease be the least possible before a kinetic focus is reached.† T variation of the action always vanishes, however, and when : action ceases to be a minimum it must become a maximum a minimax.

If the path which a particle pursues returns upon itself a if the motion is stable, a kinetic focus conjugate to the init point usually occurs at the completion of the circuit, coincidi in position with the starting point. Even when this is not t case, however, the action for an entire circuit is the same the disturbed path as on the undisturbed path. That it is t same up to the last kinetic focus before the circuit is compl is evident. The starting point may be arbitrarily chosen a may therefore be taken at a point where the movement is p pendicular to the line of force. This line then cuts the (

* Thomson and Tait, Nat. Phil., § 332. † Nat. Phil., § 358, et seq

turbed and undisturbed paths at the end of the circuit at right angles, and the action from the last focus to this line on each path is consequently the same.

Whatever the recurrent path of a particle may be, the action upon it will be the same as it would be on a circle of appropriate diameter upon which the particle should move at its mean velocity, completing the circumference in the same time which it occupies on the real path. This condition of the equality of time implies that, if $d\vartheta$ is the elementary angle which the radius of the circle makes with a fixed radius, $d\vartheta = dt$. If the mean velocity of the particle is u, the elementary circular arc is $udt = rd\vartheta$ and consequently $u = r$. Now the area of the circle is

$$\int_{t_1}^{t_1} \frac{r^2 d\vartheta}{2} = \int_{t_0}^{t_1} \frac{u^2 dt}{2} = \int_{t_0}^{t_1} \mathrm{T}dt,$$

T being the kinetic energy of the particle in its real path per unit of mass; the area of the circle is therefore half the action of the particle per unit of mass for an entire circuit. The ratio of the area to the circumference of a circle is of course the greatest possible. This ratio is $\frac{r}{2} = \frac{u}{2}$ and if the length of the circular path is regarded as the independent variable and as a given constant, say s,

$$\frac{su}{2} = \int_{t_0}^{t_1} \mathrm{T}dt = \max.$$

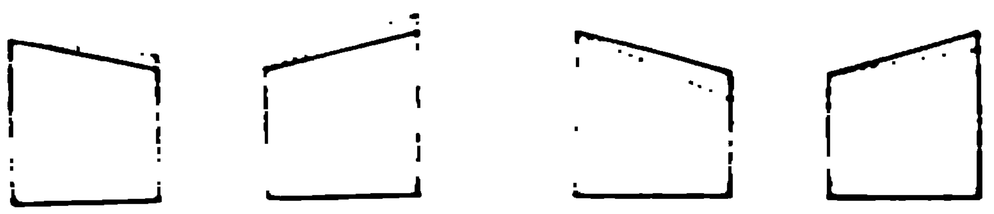
In comparing the mean velocity, the corresponding path, and the product, or the action, one or other, must be considered as given, and the conclusion that one-half the action for an entire circuit is the greatest possible is therefore entirely general.

In cases where the disturbed path returns to the same starting point as the undisturbed path, the action for an entire circuit cannot be an absolute maximum, because the action is the same on various paths between the same terminal configurations, but a proof independent of that in the last paragraph can be given that the action will differ infinitely little from an absolute maximum. Any circuit must be reversible, or the action must be the same in whichever direction the particle traverses the path. As has been shown, the action for an entire circuit is constant and the action for an infinitesimal movement is the least possible. The action from the starting point over the real path, back to a position infinitely near the starting point, is therefore a constant minus a quantity which is the least possible, and is therefore the greatest possible. It also differs infinitely little from the action for an entire circuit.

The theorem of greatest action admits of a further important extension. If we suppose a material point revovling about an attracting center and if, during the revolution, the position of the center of attraction is suddenly changed without altering its distance from the material point, this will immediately begin a new orbit without change in its total energy and the action on the new orbit will be the same as on the old one. The path, however, will not in this case return upon itself. By pursuing this train of reasoning it becomes clear that the action becomes an absolute maximum twice in every period for which the integral curvature amounts to 360° and at the expiration of which the original velocity is recovered. In certain symmetrical cases of motion a starting point may be so selected that the action becomes an absolute maximum once in every 180° of integral curvature. The interposition of a straight path upon which there is no change in kinetic energy, between two arcs, affects the proposition only by lengthening the period between successive maxima.

The two most important cases of motion for the present discussion are that of a particle of an elastic solid which is in vibration and that of a gas molecule in a confined space. In the former the particle vibrates on some stable curvilinear path about a position of equilibrium; for it is well known that a simple rectilinear vibration is an unstable motion which must pass over into an orbit or circuit when disturbed never so little. A gas molecule also pursues a stable path, for if it is rebounding against parallel walls and traversing a zig-zag course in a given plane, and if the angle is changed by an infinitesimal quantity, the disturbed path cuts the undisturbed one at finite intervals and without more than an infinitesimal digression. It is clear from what precedes that the action in both these cases becomes the greatest possible twice for every complete change of direction of 360° accompanied by the resumption of the original velocity.

The meaning of the statement that the action of a particle or a system is a maximum or a minimum for a given period is most readily appreciated geometrically. A natural motion may be supposed to begin with the same energy as a guided motion at any instant of time. Then if we represent the value of the energy of the real motion by a full line and that of the guided



motion by a dotted line, the abscissa representing the time, as in the accompanying diagrams, it is clear that the statement

that the action for a natural motion is a minimum for a given period means, that the average rate at which the kinetic energy has decreased is a maximum or that the average rate at which the kinetic energy has increased is a minimum. The assertion that the action is a maximum means that for the given period the kinetic energy has decreased as slowly or increased as rapidly as possible.

There is every reason to suppose that every natural system is conservative and that there is no natural system in which movements of various periods do not go on simultaneously. To take a simple illustration, it is impossible to vibrate an open string without exciting harmonics as well as the fundamental tone. If there is but one sensible or molar movement in a system, there is at least friction and therefore molecular motion. If we consider an open string for a period equal to that which elapses between the initial movement and that at which the fundamental movement is about to reach its first kinetic focus, it is clear that all the harmonic vibrations must have passed their first kinetic foci. The action of the fundamental motion up to this time will be a minimum and that of the other motions for the same time will be a maximum or minimax. Of the total energy of the system, then, the fundamental motion has a minimum portion and the harmonic motion a maximum or a minimax. If the fundamental motion is compared with one of the higher harmonics it is clear that the order of the latter will be a very moderate one when its action will have reached its period of absolute maximum, while the action of the fundamental vibration is still the least possible. *A fortiori* must this be the case when molar motions are compared with molecular motions or heat-giving vibrations with those which yield light.

It might be objected that since the total energy of the graver vibrations in this instance, or of any corresponding movement in any other instance, does not remain constant, the principles of the action of a conservative system are inapplicable to it. But in the first place if there is a great difference between the periods of the motions compared, the energy of the motion of longer period may be considered as constant for the time of the shorter vibration, and this assumption is commonly made in discussing simultaneous molar and molecular motions. Furthermore, if the periods are not very diverse, the movement of longer period may be reduced to the consideration of a conservative motion by supposing the energy withdrawn from it to be potentialized. For the problem in hand this treatment appears to be something more than a method of approximation; for it is well known that every complex vibratory movement may be resolved into simple vibrations. At the

extreme configurations of any simple vibration, the ener of the simple movement is entirely potentialized. The ener which is transferred from the motion of longer period to tl of shorter duration may therefore be regarded as having pass through the state of potential energy. Herein appears to the justification of the ordinary method of treating expend energy as if it were permanently potentialized.

In any case of motion involving a variety of periods, then, an interval of time just less than that which elapses between t occurrence of kinetic foci of the slowest motion is considere the kinetic energy of this motion will have decreased at a ma mum average rate or increased at a minimum average rat while for the quicker movements the decrease will not be maximum nor the increase a minimum. Hence in any ca there is a tendency of the total energy to the movement shortest period, and this tendency will be the greatest possib when the particles which vibrate most rapidly expend half tl action of the entire circuit while the action of the slowest mov ment is still the least possible. In favorable cases the diffe ence of period required to develop the greatest possible te dency to the motion of shorter period would be extremel slight, a mere fraction of the period of either movement. appears to need no demonstration that no sensible moveme can cease to be one of least possible action in a time less tha the period of vibration of a particle the movements of whi are manifested as heat. A diversity of the same order exis between the light-giving and the heat-giving vibrations as b tween the latter and sensible motion and of course a simil conclusion applies to them. The theorem propounded at t beginning of this essay thus appears to be demonstrated.

It follows immediately that the higher forms of energy ca be produced from the lower, or motions of longer period fro those of shorter period, only on condition that the sum of tl transformations of the system is equivalent to a degradation, result nearly identical with one of the chief deductions fro the second law of thermodynamics.

San Francisco Office of the U. S. Geol. Survey, Oct. 1885.

ART. XI.—*A new Law of Thermo-Chemistry;* by GEORGE F BECKER.

IN the course of an unpublished chemical investigation of process involving nearly a hundred reactions, I adopted, as guide to experiment and as a check upon the conclusions, I

helot's famous thermochemical law,* with extremely satis-
ry results.

his law, the experimental proof of which is very convinc-
applies only to the final molecular configuration of given
tances, however, and gives no information as to the series
ransformations which they undergo before reaching a con-
n of stable chemical equilibrium. But in many of the
nical processes of nature, and in some technical operations,
reactions are interrupted before the final result is attained.
ll cases it is a matter of great scientific interest to know the
governing the actual series of transformations from the ini-
to the final condition of a mixture of substance, between
ch reaction takes place.

n the course of the experiments referred to, it appeared to
that the *rate* at which chemical energy is converted into
t by various possible reactions was an important factor in
ermining the order of their occurrence. But even the de-
nination of the total thermal effects of reactions requires
remely delicate experimentation, elaborate apparatus, and
er special facilities. To determine experimentally the rate
which this heat is produced would be a still more serious
tter and was quite out of the question with the time and re-
rces at my disposal for this purpose. I therefore undertook
inquire whether, by considering chemical energy as a form
motion, any definite results could be reached as to the rate
evolution of heat. This investigation eventually led to a
ciple embracing that sought. It appears under the title of
heorem of maximum dissipativity in the preceding article.
chemical interpretation of this principle is as follows: The
of the chemical and physical transformations in any chem-
ly active system will be such as to convert higher forms of
rgy into heat, light, etc., at the greatest possible rate, pro-
ed that the interval of time for which the comparison is
le is a multiple of a certain fraction of the period of the
t rapidly moving particles of the system. For all experi-
ntal and for most theoretical purposes this is equivalent to
statement that the transformations will be such as to evolve
t, light, etc., at the highest possible rate.

his law evidently includes M. Berthelot's, of which the
ciple of maximum dissipativity affords a rigid demonstra-
. The tendency to the conservation of molecular type
ch M. Berthelot has observed in complex transformations†
seems a natural though not rigidly demonstrated conse-

Principe du travail maximum.—Tout changement chimique accomplé sans
vention d'une énergie étrangère tend vers la production du corps ou du sys-
de corps qui dégage le plus de chaleur. Mécanique Chim., vol. i, p. xxix.
léc. Chim., vol. ii, p. 471.

quence, for it can hardly be doubted that a simple substitution in an existing compound will, as a rule, take place more rapidly than a fundamental re-arrangement of atoms.

I shall have occasion hereafter to call attention to instances in which, as nearly as can be ascertained without exact determinations of rate, the order of ordinary laboratory reactions conforms to the law here announced. I desire, however, to point out without delay its applicability to a problem of geological chemistry, in which exact and direct experimentation is almost or quite impossible, viz: the order of the genetic succession of minerals in massive rocks. This is a subject of the greatest importance to rock classification and to the whole science of lithology. It is also one in which little or no advance has been made.

No *a priori* guess could be more natural than that the order of succession of minerals in eruptive rocks is that of their fusibility. Indeed, this corresponds closely to the old empirical (and incorrect) rule of chemistry, according to which precipitation takes place whenever an insoluble compound would result from any re-arrangement of molecules. Nothing is more easily confuted, however, than this hypothesis of genetic succession, if rigidly interpreted, since magnetite, for instance, is among the first and among the last minerals to form in several eruptive rocks. Bunsen, too, has shown that the temperature at which an isolated body solidifies is never that at which it separates in the solid state from its solutions.* This fact does not appear to me to show that the order of succession has no connection with the fusibility, as is sometimes stated,† but only that if such a connection exists, it is not an entirely simple one. There are coincidences between the order of succession and the order of fusibility of the mineral species composing massive rocks which it is scarcely possible to regard as accidental. Thus zircon and olivine are among the first minerals to solidify, and their only common characteristic appears to be a high degree of infusibility. The highly refractory quartz, too, is an early mineral in the quartzose porphyries, and sometimes, also, in granite. Messrs. Fouqué and Michel-Lévy were, I believe, the first to show ‡ that in the following triclinic feldspar series; anorthite, labradorite, oligoclase; the crystals of primary consolidation almost always precede the crystals of secondary consolidation. They have also shown§ that this is the order of the fusibility of these minerals, while Professor Szabo finds that bytownite and andesine occupy a position in the scale of fusibility similar to that which they occupy in the scheme of chemical composition.

* Zschr. Geol. Ges., 1861.

† Roth, Allgemeine u. chem. Geol., vol. ii, p. 48.

‡ Min. microgr.

§ Comptes Rend., 1878.

The hypothesis that the order of genetic succession is that of increasing acidity has been advocated, I believe, only for granitic rocks. Even for these it is not rigidly true. The order in which the feldspars appear in volcanic rocks, however, is also one of increasing acidity, as well as of increasing fusibility. Such relations between chemical composition and fusibility are of course extremely frequent, especially among organic compounds. Messrs. Fouqué and Michel-Lévy also found albite more fusible than labradorite and less so than anorthite. Those who regard the plagioclases as isomorphous mixtures of anorthite and albite must, therefore, consider oligoclase as the most fusible mixture of the two, while it also appears to be commonly the last feldspar to crystallize. A similar maximum fusibility is known to exist in other series. Thus the fundamental slag of iron blast furnace practice is an exact bisilicate of the form $4CaSiO_3 + AlSi_3O_9$. This is the most fusible compound of these ingredients, any alteration in the acidity or in the ratio of the bases rendering it more difficult of fusion. Oligoclase contains more aluminium than the slag, but also sodium.

It thus appears that while the chemical composition and the fusibility of the rock forming minerals are most intimately connected, neither of these properties affords an adequate explanation of the order of genetic succession, nor does any known combination of them explain the facts. That the fusibility at least is not without effect upon the order of succession seems highly probable, but, if so, there are other concomitant influences which very materially modify the results.

If the changes which occur in cooling eruptive magmas obey the laws of thermo-chemistry, the somewhat confused relations actually observed between genetic succession, fusibility and acidity are just such as might be expected in advance. There is every theoretical and experimental reason to suppose that the fluid eruptive magma consists of one or more compounds differing essentially from the minerals eventually formed from it. In cooling it must therefore undergo a series of chemical and physical changes. The formation of any new stable chemical compound, whether fluid or solid, in the mass converts other forms of energy into heat; but, at the same time, the subtraction of any such group of molecules from the previously existing combination alters the chemical constitution of the residue. It is quite conceivable that the change in the residue should involve either an absorption or a liberation of heat, but if the former and if this were to exceed the positive thermal effect of the supposed stable compound, the whole operation would be impossible. In general, if no physical change accompanies the alteration of chemical configuration, that chemical change and that only will take place through which heat is liberated most rapidly.

It is not sufficient, however, to consider the chemical trans mations by themselves, for these are in general accompanied physical alterations in the mass. Much the most importan these is solidification, which is always accompanied by a lit ation of heat.* Now the amount of heat evolved by the so ification of compounds is of the same order as the therr effect of chemical combination. Since therefore the sum the chemical and physical changes must be such as to deve the maximum amount of heat per second, let us say, the f that heat is liberated by solidification establishes a distinct t dency to the formation of solid precipitates; but this tender is only operative on condition that by no other transformati can heat be more rapidly liberated.

In view of these considerations it seems almost certain tl the order of genetic succession of minerals will sometimes f low the order of separate solidification, but that in a greater smaller proportion of cases there will be essential differen between the two orders. Thus there is no difficulty in und standing that at a certain early stage in the cooling of an eru tive mass, the rapidity of the evolution of heat may be p moted by a separation of a portion of the iron as magneti while the separation of the entire mass of this mineral at tl stage would be incompatible with the most rapid possible e lution of heat by the entire simultaneous chemical and physi changes then progressing. So also if two magmas of simi qualitative but different quantitative compositions are co pared, it does not seem remarkable from a thermo-chemi standpoint that augite should separate before labradorite in t one and labradorite before augite in the other (andesite a basalt).

In one sense the above discussion is of little value to lith ogy. The new law of thermo-chemistry does not enable o to state what will be the order of genetic succession of min als under a given set of chemical and physical conditio This is because the total thermal effect of many of the ro forming minerals is unknown, while, so far as I am aware, t rate at which reactions evolve heat has not yet been studied exact methods. But the law at least explains why neither fu bility nor basicity obtains complete control of the process a how it may happen that the order of succession which preva in one set of cases may be reversed in another. The n principle governs the genetic succession of minerals in er tive rocks, but the constants of the equation in which it m

* Solidification of course takes place at a lower temperature than fusion. ' appears to be a theoretical necessity, for if any small fraction of a mass we solidify at the melting point, the heat evolved by the act of solidification w raise the surrounding temperature above the melting point and the solid par would melt again.

be expressed remain to be determined. The number of these constants will doubtless be diminished by future generalizations and the application to lithology thereby simplified.

Since the rate at which heat is evolved in a solidifying lava is the greatest possible, the rate at which it cools, other things being equal, must be a minimum. This fact must have an important influence on the flow of eruptive rocks and probably accounts in part for the power which they possess of penetrating the tiniest cracks as dikes.

San Francisco Office U. S. Geol. Survey, Nov., 1885.

ART. XII.—*Recent Explorations in the Wappinger Valley Limestone of Dutchess County, N. Y.;* by WILLIAM B. DWIGHT.

No. 5.—*Discovery of fossiliferous Potsdam Strata at Poughkeepsie, N. Y.* (Illustrated by a map, Plate VI.)*

THE presence of rocks of the Potsdam group in association with the limestones and shales of Dutchess County, N. Y., has long been suspected on stratigraphic grounds, but until the present time this fact has never been proved by positive paleontological evidence.

At the bases of Fishkill and Stissing Mountains, a thick stratum of quartzyte is found between the underlying Archean of those mountains, and the overlying limestones, now known to be respectively Calciferous and Trenton. This quartzyte shows planes of stratification, and is conformable to the overlying strata of limestone. Obviously, by its stratigraphic position, it appears to represent the Potsdam group, and this assignment has been made for it, in the localities mentioned, by Professor Mather, Professor J. D. Dana and others.

Notwithstanding that considerable search has been made, no fossils have yet been found in this quartzyte-stratum, by which this reasonable hypothesis might be established. I am not aware that any geologist has heretofore found reason to suspect the presence of a Primordial stratum among the limestones of the region, and certainly I have had no such expectations myself. The observations made during the last few years in the Wappinger Valley (or "Barnegat") limestones, have definitely proved them to be composed extensively and continuously of conformable strata of the Calciferous and Trenton groups. In carrying out the work, in which I have for several years been engaged, of preparing a detailed stratigraphical chart, on April 25th of the present year, to my great surprise,

* Read before the American Association for the Advancement of Science, at Ann Arbor.

I struck a ledge of rock in the Wappinger Valley limestone belt, which proved rich in Potsdam fossils.

This remarkable locality is on an estate owned by Mr. Albert K. Smiley, proprietor of the Lake Mohonk House. It is in the outskirts of the city of Poughkeepsie, to the southeast. It is about one mile southwest of Vassar College, 850 feet south of the southwest corner of the Driving Park on Hooker avenue, and about 2200 feet west of the road which passes south along the east side of the same.

The Potsdam rocks are found in a series of low hills or ridges trending northeasterly and southwesterly in parallel lines. The most interesting paleontological features appear to be concentrated in a ridge lying at the northeast corner of the group (Hill A, Plate VI). This is situated immediately to the southwest of Smiley's detached barn, which is itself south of the southwest corner of the Driving Park. This hill is about 300 feet wide and 1400 feet long; it is mostly covered with soil, the rock cropping out on each side, but chiefly on the east, in a few narrow, quite inconspicuous ledges; it would never have attracted my attention but for its occurring within the range of a systematic survey.

Lithologically this Potsdam rock is exceedingly variable, and all the varieties described occur within the small compass of a few acres of ground. It is everywhere (so far as already examined) calcareous, all its varieties effervescing with acids. It is also everywhere more or less arenaceous; often conspicuously such. Large portions of it are a tough, compact limestone, often quite dark, and frequently filled with a conspicuous fucoid-like tracery; the weathered surfaces are often rough with sand-grains. This variety passes into one which differs chiefly in being fissile into more or less thin slabs; this variety often alternates with layers of exceedingly thin and friable shale, the folia of which are covered with loose sand as they decompose.

The rock also passes on the one hand into argillaceous varieties represented by a smooth, fine-grained, massive argillaceous limestone well exhibited on the west side of the main fossiliferous hill; and represented also by a very fissile and smooth calcareous shale, well shown in a hill (E) which is a continuation, in the second field south, of the above-mentioned hill. Although nearly as fissile, this variety differs essentially in appearance from the closely adjoining Hudson River shales, which are much darker, and more glazed or shining on their surfaces. On the other hand, this Potsdam rock passes into a very solid, massive quartzyte, the fine sand-grains of which are everywhere in absolute contact, so that in appearance it is only a grade less compact than the quartzyte of Stissing Mountain;

the minute interstices are occupied by calcareous material, ıat the rock effervesces a little under acids.

ı many places, again, the material takes the form of brec- ɜd conglomerate; this is well shown in the western Potsdam at the northern extremity of the tract under consideration l B), and its extension south into the next field (Hill D); in the western marginal Potsdam ridge just south of T. A. kle's house in the next field.

'he southeastern extremity or fork of the main fossiliferous (A) is a solid mass of peculiar oölyte, made up of spherules ch are simply aggregations of rhomboidal calcite crystals ›edded in the interstitial mass of quartzyte or calcareous ,rtzyte. I have found pebbles of this peculiar oölyte in the glomerate above mentioned in the ridges of the western rgin, suggesting a later date of deposition for the latter. In ny places these Potsdam rocks exhibit very distinctly oblique ination.

[he strike and the dip are quite variable. The most general ke of these Primordial strata appears to be about N. 21 E. ıe), and the most general dip about 55° easterly. Some fur- r statements as to local variations will be given subsequently.

n order to determine the true stratigraphic relations of these sdam and related strata, I have made a special detailed mination of a district covering about a mile and a half are in the vicinity of this locality, and embracing about a e and a quarter of longitudinal extension in the direction of strike. This district is mapped in Plate VI.

[his Potsdam rock is one of the component members of the st western, and by far the broadest of three parallel belts of Wappinger Valley limestones, which, in this vicinity, rise ween the Hudson River shales. In general, all these lime- nes and shales lie in a series of abraded folds, having usually onformable strike of from N. 20° E. to N. 30° E. These ls are closely compressed, and pushed over to the west, so t the earlier limestones usually overlie by inversion the later les lying to the west of them.

[he particular belt of limestone which stretches southwest m the Driving Park is about 3500 feet in width at its thern extremity, and about 6000 feet wide at the southern tion of the limited district now under consideration. This ıthern transverse line of 6,00 feet passes through the middle the estate of W. S. Johnston on the Albany Post Road.

[his belt terminates toward the north, quite abruptly, along almost straight line which cuts it apparently at a right angle the strike. This line runs along the southern margin of the iving Park, continues east through the fields parallel to ɔoker avenue till it meets the Hudson River shale in the

meadows of Casper Creek. Immediately north of the Driving Park, in fields on the north side of Hooker avenue (locality O, plate VI), in place of limestone there are hills of Hudson River shale, and this same rock crops out along Hooker avenue to the west all the way to Casper Creek and beyond. From this line these shales continue unbroken many miles to the north beyond Hyde Park. Along this northeasterly and southwesterly line, the intervening space between the outcrops of shale on the north and of limestones on the south consists of a mostly level strip of drift having bogs and springs along its southern edge. Evidently this is a line of fault, across the strike, between the Hudson River shales on the north and the Potsdam, with its associated Calciferous and Trenton, on the south. This trough, cut through the hilly ridges, is a conspicuous feature in the local landscape. It is made available for traffic by the avenue that passes through it obliquely into the city; it furnishes the long and smooth plat (mostly underlain by the shales) which constitutes the Driving Park.

The stratigraphic relations of the western margin of the belt of Potsdam have proved far less obvious than those of its northern extremity. But after a careful detailed inspection of the ground, a correct solution, as I believe, has at last been reached. During the earlier examinations, Calciferous or Trenton strata were naturally looked for, in intervening folds, between the Potsdam and the Hudson River shales to the west. The western hill of conglomerate above mentioned (Hill B) and its southern extensions, were at first taken to be the Trenton coralline conglomerate which occurs abundantly in the vicinity. But on further investigation, two facts were developed which opposed this supposition. The first fact was that the lithological constitution differed entirely from that of the Trenton wholly-calcareous conglomerate, in being highly arenaceous, as also in the entire lack of the microscopic corals which abound in the Trenton. On the other hand, its lithological characters are quite in harmony with those of the adjoining ledges known to be Potsdam.

In the second place, an outcrop of the Hudson River shales was discovered close to the western base of this hill, within a few feet, thus marking the line as the actual western limit of the limestone. This limit is at the most but 300 feet west of the fossiliferous Potsdam strata, a space by no means sufficient to allow the presence of Calciferous and Trenton strata of the usual thickness exhibited in the region. A further study of all the phenomena makes it quite certain that the Potsdam extends to the western margin of this belt of limestone, in its entire southern extension through the district examined. This limestone margin (as traced from the north) is broken by three

or four jogs, as the belt widens to the west, until the field next south of T. A. Hinkle's cottage is reached; from that point it is nearly straight. Close to this line, at the distance of a few feet throughout its entire length, there are many outcrops of Hudson River shale which continue west to the Hudson River, unless Utica shales may occur at some points. The shales are in many places separated from the Potsdam limestone by lines of springs and ponds, or by dry gullies. From the extreme northern end, the plane of contact is marked by a line of ponds nearly to Hinkle's house. Close to this house, to the west of it, there is a deep gully, with the limestone on which the house stands, on the east, and the shales, standing nearly vertical in a bold exposure, on the west. This gully continues to mark the line to the southwest as far as the turn in the Ferris road, beyond which the demarcation is produced by a different but no less striking plan; for south of this point the limestone remains a high conspicuous ridge, abruptly steep on the western side, while the shales, mostly covered by drift, form a level plain at its base.

These facts make it evident that there is also a line of fault between the Potsdam and the Hudson River shales at the western margin of the limestone belt, more or less parallel to the strike. The general direction of this line of fault is about N. 40° E. The Potsdam strata near the line of contact are generally deflected in such a way as to have less easting in the strike, which is in such places from N. 4° E. to N. 11° E. Thus at the extreme north end of the main fossiliferous hill (A) the strike varies between the limits just given, while the dip becomes as low as 20°. At the hill of calcareous quartzyte in the third field south of the Driving Park (Hill F) the strike is in some places N. 11° E., and the dip 35°.

On the other hand, the Hudson River shales incline to acquire more easting in the strike, in the vicinity of the plane of contact. In such cases they have quite frequently a strike of N. 46° E. (their general strike in the vicinity being about N. 31° E.). They also, in such positions, are often found inclined at a very high angle. These phenomena seem to indicate considerable friction by a lateral motion in a northeasterly and southwesterly direction, as well as in the upward motion, at the time of the uplift of the Potsdam. This fault is the more interesting, because it is evidently related to the great fault described by Sir William Logan and Professor James Hall as extending from Quebec to the Hudson River near Rhinebeck. If, as has been suggested by Professor J. D. Dana, this should more properly be regarded as a series of more or less parallel faults, the present one would constitute the most southern one of the series yet described.

With regard to the eastern boundary line of this strip of Potsdam nothing definite can be determined from present data. There are no fossils to indicate the points of transition to the Calciferous and Trenton, which doubtless lie in abundant development to the east. The uncertainty is increased by the fact that a great part of the rock is deeply buried under drift. Thus, at the northern extremity, east of the fossiliferous Potsdam, after about six hundred feet of strata (which are probably to some extent at least of the same group), the limestone entirely disappears under a large hill of more than fifty feet depth of drift in A. Vanderberg's farm. (This hill is so covered with debris of Hudson River shale that one might readily suppose it to be the rock in place.) The limestone does not reappear until the southeastern base of Richmond Hill on Casper Creek is reached. That this eastern margin of the belt is Trenton is proved by a distinct outcrop of fossiliferous Trenton filled with *Solenopora compacta* ("*Chætetes compacta*") appearing in a small patch on a hillside 520 feet from the house of R. J. Kimlin on a course of N. 101° E. The Calciferous is doubtless extensively represented between the Trenton and the Potsdam, but this has not been paleontologically determined.

In view of the above facts, I can make only the general statement that the minimum width of the belt of Potsdam strata, measured on the surface of the ground, is somewhat over 600 feet. If, as seems probable, there is at least one compressed fold, the actual thickness of the deposit must be over 300 feet.

It is my present impression that the Potsdam folds occupy, as indicated on the accompanying map, a strip of about 1400 feet in width, and that the high and continuous limestone hill (K) on the east of this strip may form the western margin of the Calciferous strata. In this case the small quarry in the field of W. S. Johnston, at the southeastern portion of the district (H), would be near the eastern edge of the Potsdam. This view is strengthened by the fact that lines of ponds and springs exist conspicuously along the base of this long eastern hill, indicating a possible break or slip between strata along this line. But as fossils have not yet been found in the last mentioned hill, nothing more positive can be asserted in this connection at present.

A brief description may now be given of the paleontological features of these strata.

In the fossiliferous hill above described (A), organic remains are found chiefly on the eastern side near the summit in the southern half, though not in the oölytic portion. They occur both in the solid fissile limestone, and in thin layers of shale

sociated with it. The fossils are present in considerable mbers, but so much scattered through the rock that large isses must be broken up to obtain a few organisms.

I have also found a few specimens of Lingulepis in the tension of the western fork of this hill in the second and ird fields beyond, where it becomes a blue calcareous shale (E).

No fossils have yet appeared south of Mr. Smiley's property, at is, south of the fourth field from the Driving Park, except me Stromatoporoid forms which are not infrequent throught the Potsdam strata. From these localities I have already llected over 500 fossils; some of these are in a perfect state preservation, while many are in a very imperfect and fragentary condition. There is no doubt whatever as to the esence among them of several well-known and well-marked otsdam fossils, while the whole group appears to belong to at geological horizon. Since, in my explorations among ese limestones during seven years, all of the abundant fossils und have indicated the presence of either the Calciferous or of e Trenton formations alone, I have not failed to consider the iestion carefully whether the present fossils, though of a otsdam type, may not after all exist here in Calciferous rata. But I have found no facts to favor the latter supposion. The rock is lithologically considerably different from iy known fossil-bearing Calciferous in Dutchess County. he fossils are all of the type so well known in the Potsdam cks of New York State and of Wisconsin, while no single renton or Calciferous fossil of the vicinity or of any locality, s appeared among the hundreds here collected.

These fossils will require a very careful study for a full deterination as to the number of genera and species. The followg preliminary statement will indicate their nature in general.

Lingulepis pinniformis; several specimens of both valves, some of which are quite perfect.

Lingulepis minima; many specimens of both valves.

Lingulepis acuminata, probably; several good specimens.

Obolella (*Lingulella*) *prima;* several specimens.

Obolella; a minute species resembling "*Nana;*" one or two specimens.

Platyceras; undescribed species; one or two.

Remains of small encrinal columns; several.

Ptychoparia (*Conocephalites*); n. sp. resembling *Iowensis*, but possessing an occipital spine; several glabellas and pygidia.

Dicellocephalus; two or more species; undetermined; numerous specimens.

Ptychaspis; one or more undetermined species; several specimens.

Stromatocerium? undetermined; abundant.

The more abundant of these fossils are the *L. minima*, whose fragments are thickly scattered through some portions of the shaly limestone, and next the movable cheeks of trilobites.

It will be observed, as has been suggested to me by Mr. R. P. Whitfield, that the fauna of this locality forms a connecting link between the known fossils of the Appalachian region and those of the Western States. Thus with the *Lingulepis minima* and *L. acuminata* of the New York Potsdam is found the *Lingulepis pinniformis* of Wisconsin and other western localities.

It may also be remarked that the fauna of this Poughkeepsie locality, as far as at present developed, is quite distinct from that of the Potsdam strata recently discovered by Mr. S. W. Ford at Schodack Landing and other places in the town of Stuyvesant, N. Y. From these localities, lying about fifty miles north of Poughkeepsie, Mr. Ford reports (this Journal, July, 1884) the following eleven species: *Paleophycus incipiens*, *Obolella crassa*, *Stenotheca rugosa*, *Hyolithes Americanus*, *H. impar*, *Hyolithellus micans*, *Microdiscus lobatus*, *M. speciosus*, *Conocoryphe trilineata*, *Olenellus asaphoides*, and *Fordilla Troyensis*.

No one of the above list has been found at Poughkeepsie; the distinctive character of the two faunæ is evident, the latter apparently representing an earlier stage of life.

The discovery of the presence of fossiliferous Primordial rocks among the Wappinger Valley limestones, while it adds an extremely interesting feature to the geology of the region, contributes another complication to the difficult task of mastering the stratigraphy of Dutchess County.

Vassar College, Poughkeepsie, N. Y., June 25, 1885.

NOTE.—Since the above paper was written I have conducted these researches further, and have traced the continuation southerly of the fault between the Potsdam and Hudson River shale to the bank of the Hudson River. This line, which had been traced previously only into W. S. Johnston's farm, has been found to continue, well marked as before by ponds and gullies, in a straight line till it crosses the Albany post road at the corner of the New Hackensack road near School House No. 2. On the west side of the post road it passes straight across R. T. Gill's farm, then crossing the road leading to the Milton Ferry, and striking between the two roads leading in a southwesterly direction to the river. It terminates finally in a high bluff on the river near Mallory's Moulding Sand Dock and about one mile north of Clinton Point post office. Throughout this course the Primordial limestone and the shales show themselves frequently in close proximity in outcrops. In Gill's farm both formations are mostly covered by hills of drift, but on this farm, just north of the Milton Ferry road, both the Potsdam limestone (here as calcareous shale) and the Hudson River shales crop out distinctly. The latter yield at this locality some very excellent and characteristic fossils, as encrinal columns, *Leptæna sericea*, etc. The terminal bluff at the river is composed of *both* formations, the fault running along its summit, but near the northwestern edge. As the extreme southwestern point of the bluff is reached, the line of fault drops down its northwestern side, and the shales at last disappear, leaving the point in possession of the limestone. After careful examination I am satisfied that some, if not all, of the moulding sand is produced by the decomposition of the arenaceous Potsdam. Indeed, the process may now be seen going on

the layers of the sandy limestone. It is very probable that the Potsdam may ›w be further traced across the Hudson River somewhere near Marlborough.

In Plate VI will be found a small map showing the entire extent of the fault ›ove described.

It is proper to state here that I have strong reason to suspect the presence of a parllel belt of Potsdam limestone, more than a mile to the east of the present one, in he most eastern of the three belts of limestone. The particular locality which has urnished grounds for the above statement is on the summit of the ridge about ıalf a mile southerly from the mansion on the MacPherson (late Boardman) place. The rock corresponds closely in its lithological characters with that of the Smiley locality. I have found here but a single fossil—about half of one valve of a brachiopod, which as far as it goes corresponds perfectly with *Lingulepis pinniformis*. I believe it to be this fossil, and that consequently the rock is Primordial, but cannot say that the evidence is absolutely conclusive.

EXPLANATION OF PLATE.

A, Hill of fossiliferous Potsdam on Smiley's farm.

B, Hill of Potsdam, partially conglomerate, on Smiley's farm.

D, C, extensions of hill B. D is largely conglomerate.

E, Hill containing much fine-grained, blue, thinly fissile calcareous shale of the Potsdam group: a few specimens of *Lingulepis pinniformis* have been found here.

', Calcareous quartzyte, Potsdam group.

The lane between the wall and fence just south of the hills E and F is the ›uthern boundary of Mr. Smiley's farm; at present date no Potsdam fossils, ex›pt stromatocerium, have been found in this belt south of this line.

, one of the best localities for inspecting the Potsdam limestone and calcareous shale composing this long hill. Stromatocerium is found here. From the summit of this hill a good view is presented of the wide plain of Hudson River shale which extends westward from its base.

., a small quarry of arenaceous limestone apparently Potsdam, in the field belonging to W. S. Johnston.

a high ridge of light- and dark-colored limestones, well exhibited at the spring here indicated; horizon of the rocks doubtful.

., outcrops of Hudson River shale at the surface of the ground within a few feet of the Potsdam hill B.

, small quarry of compact, gritty layers of the Hudson River group, dipping at a low angle.

', hilly outcrops of Hudson River shale in field north of the driving park.

L (in small included map), molding sand, and dock.

', (in small included map), outcrops of fossiliferous Trenton on the eastern margin of this limestone belt.

ART. XIII.—*Wind Action in Maine;* by GEORGE H. STONE.

DRIFTING sands of the ordinary type are very common in Maine, especially in the western half of the State. These sands are partly of marine, partly of fresh-water deposition. All of the large rivers of Maine, except the Penobscot, covered large areas with sand near where they emptied into the sea during the Champlain epoch, the sea of that period being, as is well known, somewhat more than 200 feet above its present level. For various reasons the drift of the Penobscot valley differed considerably from the valley-drift of any other large

stream of New England. The valley of the Androscoggin preëminent for its sand dunes. One can travel in a carria along this river from Brunswick to the New Hampshire line Gilead and hardly be out of sight of drifted sand for an ho at a time. In Wayne, within the last forty years, the sand h drifted eastward from one half a mile to nearly one mile, ai up the western slope of a hill 250 feet high, and now is descen ing the eastern slope. In places the dunes must have travel two miles or more away from the river valley where they we originally deposited as valley-drift. Often on hill-sides a pir growth is found where one would naturally expect the har deciduous trees. Investigation shows that drifting dunes hav passed over the hill, and have left more or less sand as a cove ing of the till. The explorer of the drift of Maine soon come to regard this blown sand as perhaps his most protean adve sary, especially when trying to locate the shore line of th Champlain sea. It is not, however, the purpose of the preser writing to treat in detail of the ordinary dunes, but to describ two less common phases of wind action.

I. *Till Burrowing.*—Not rarely spots bare of vegetation ca be found on hill-sides exposed to high winds. Here during dr days the wind removes the finer parts of the till and drives th gravel back and forth just as happens in Colorado during th dry winter weather. But the rains fall so frequently in Maine and the ground during the winter is so generally covered wit snow, that under ordinary conditions the wind is never able t blow away much of the till in this manner. A few inches i all that I have ever seen thus removed. But along the border of the drifting sands the case is different, especially near th tops of hills where the till is not kept moist by springs. Her the protecting vegetation has often been destroyed over larg areas by the drifting sand, and the rapid evaporation from th sand seems to keep the till dryer than elsewhere. As a resul the till is here blown away much more rapidly than usua Small bluffs are formed, partly owing to the direct effect of th wind in blowing away the finer parts of the till, and partly fro the impact of the blowing sand which is near by. A talus com posed of the coarser gravel and bowlders of the till is thus le at the base of the cliff and scattered promiscuously over the de nuded surface. In this way considerable areas of the till hav in some cases been denuded as the drifting sand traveled fro place to place. A fine instance of this kind of till-burrowin is found on the top of a hill about one mile northwest o Wayne village. Here, in 1879, the wind had excavated the til to a depth of nearly three feet and the glaciated ledges ha been laid bare for a distance of several rods. The glaciated stones of the till retained their scratches in perfect condition,

'ing that the process of denudation had been so rapid as ;o permit much weathering of the stones or much sand-ıhing.

. *Sand-Carving.*—In Professor C. H. Hitchcock's Report ıe Geology of Maine for 1861 (pp. 266–8) reference is made peculiar train of bowlders found by Dr. N. T. True at Bethel, ne, and described by him before the Portland Society of ural History. A part of Dr. True's description is as fol-ı: "I wish now," says Dr. True, "to call your attention to llection of bowlders of a peculiar character found in Bethel, ıis State. These bowlders are scattered over the surface ıe soil for several square miles. On one side may be seen)ves, scratches, strial and polished surfaces. Nothing of is seen on opposite sides of the same rock. The opposite ace is usually angular, as if it had not been subject to ısion since its detachment from the parent rock. Fre-ntly, as in the specimens before you, may be seen sharp les formed by a different presentation to the abrading sur-. Sometimes the grooves present an undulating surface f it had been subjected to a tremulous movement from the ending mass. * * * There is a freshness in their appear-ɜ as if they had been grooved yesterday. They present no earance like rocks on the sea-shore, which have been ex-ɜd to the action of water. They are composed of granite, nblende, and grey-wacke slates." Professor Hitchcock re-ks (loc. cit.), "the bowlders in Bethel are very curiously ɔed; and it is not easy to say how these shapes were pro-ed." Dr. True sent some of them to President Edward ːhcock of Amherst, who under date of Jan. 16, 1854, writes: am very much puzzled with the specimens. They are dif-nt from anything I have seen, and deserve careful study. grand point of difficulty is to account for the bowlders ıg held in so many different positions in order to be tched, or rather grooved, for the striæ are different from e in common rock." Both President Hitchcock and Dr. e thought that the peculiar form of these bowlders was due ceberg action, a very natural view considering the then 'alent theories as to the origin of the drift.

he writer first studied these bowlders in the field in 1879, n they were pointed out to him by Dr. True himself. At time, in addition to the characteristic bowlders in the nity of Bethel, I found one of precisely the same character Gilead, also one about a mile east of Gorham, New Hamp-e. (Dr. True thought they were only to be found at ıel.) It will be seen that these localities are all near the lroscoggin river, and but a few miles from the White ıntains. The unusually carved bowlders were all found

on hillsides above the level of the valley-drift and mos them were on the south side of the river on slopes well posed to the north and northwest winds. In fields and by road-sides in Bethel, where the bowlders had probably n been disturbed by plowing, I made note of the positions of polished faces of hundreds of the bowlders. The polished faces were turned in every direction, but more faced the and northwest. Dr. True's observation that one face of t bowlders is usually unpolished was verified, though in one a bowlder was found polished on all faces. In the majorit cases this unsculptured face was *the lower face.* In the 1880, I deposited specimens of the Bethel bowlders in the c net of the Boston Society of Natural History, and submi them to several glacialists for examination. But during al this time none of us obtained any inductive clue to the n tery—the cause of the peculiar carvings. In 1881 I remo to Colorado and for the first time saw in the field the sa sculptured bowlders so common in the arid regions, and t forms were seen to be the same as those of the Bethel bowl Here at last was an opportunity to leave speculation for a v induction. At once several theories were suggested as acco ing for the peculiar shapes of the Bethel bowlders, but it been necessary to wait for several years in order to deterr by observations in the field which one is the true hypoth Three of these alternatives are here stated and briefly cussed because they bear on the question of the causes of shapes of the drift materials, and this is sure to be a pres and significant question for glacialists to solve.

1. These bowlders may have been sand-carved by the v in their present positions, and recently. If true, this hypo sis could easily be verified by finding the process now in eration.

2. They may have been sand-carved by the dashing of rain chiefly. That this is a cause of sand-carving there ca no doubt; but if such extraordinary forms as those at Be are due to this cause, then similar surfaces ought to be c mon everywhere, unless there is something in the Bethel bo ers fitting them to receive or preserve such polishing be than other bowlders. But on the other hand they are ordinary drift bowlders, representing various common ro they are neither harder nor softer than many others, nor they resist weathering any better. Many of them are of a v feldspathic granite, while in others quartz predominates.

3. They may have been sand-carved by glacial strea Whenever swift sediment-laden streams impinge obliq against a rock surface, that surface is carved into tremu grooves showing many sub-conchoidal depressions very ne

like the Bethel bowlders under consideration. On the average, the depressions are perhaps shallower in proportion to their breadth when made by water, than when the abrading agent is driven by the wind. This kind of sculpturing I have seen in a great many places both in Colorado and in Maine, almost everywhere, in fact, where the rock does not weather faster than the streams can polish the surface. Fine examples can be seen at the Rumford Falls of the Androscoggin, also at the High Falls of the Saco, near Hiram. Crystalline rocks are more likely to show this kind of eroded surface than sedimentary rocks, unless the latter are very firmly cemented.

So far as my observation goes, sand sculpturing by flowing water only takes place when the water strikes against a surface that is stationary for a considerable time. This is not likely to happen except in case of the solid rock or of bowlders of considerable size. The swiftness of current necessary to produce sand-carving will from time to time roll the smaller stones and bowlders into new positions. The attrition and concussion of the stones against each other so modifies the forms due to the sand and gravel driven by the water that the stones are rounded into pebbles, and do not receive the peculiar conchoidal depressions and tremulous groovings due to pure sand-carving. Thus, for instance, in the beds of the swift streams of the White Mountain region, the fall is often 100 or more feet per mile, and the bowlderets and smaller stones are well rounded like beach or Kame pebbles and cobbles. Some of the Bethel specimens are only two or three inches in diameter, too small to have been sand-carved by water under ordinary conditions. But Bethel was not far from the end of the local Androscoggin glacier, and it may be said that it is possible that the peculiar carvings were due to sediment-bearing sub-glacial streams acting on stones and bowlders which were for a time held fast in the ice. At several points in the Androscoggin valley, between Gorham, N. H., and W. Bethel, Me., I have found surfaces of the solid rock grooved lengthwise of the valley, i. e., nearly parallel with the flow of the local glacier, which it is well known lingered here for a time after the great ice-sheet had melted. These were not the ordinary glacial scratches, but had the gouged appearance and conchoidal depressions made by sand-laden water. Some of these places were above the highest level of the river during the Champlain floods. A fair inference is that the unusual grooves were probably due to the muddy sub-glacial streams of the local glacier. But even if we admit sand-carving of the underlying rock by sub-glacial streams, can we do it in the case of moraine stuff held in the ice? I have failed to find any recorded observation on this point, though the Alpine glaciers ought to afford facilities for such observations. If

at Bethel bowlderets and smaller stones were held so long in one position in the ice as to be sand-carved, then, either such sculptured surfaces ought to be common in the kames, or we must re-cast our theories as to the kames being deposited by glacial streams. During an investigation of several years, the writer has failed to find a well marked instance of pure sand-sculpturing in the kames and osars, though now and then there are indistinct traces of it.

During the past summer the writer, in the course of an investigation of the glacial gravels of the region, has explored the Androscoggin valley from Brunswick to the N. H. line. Incidentally the Bethel mystery was solved. In numerous places, both in Bethel and elsewhere near the mountains, I found bowlders and even small stones which are now being sand-carved *by the wind* as plainly and incontestably as in Colorado. The drifting dunes of fine sand do not produce this effect to any great extent, probably because the stones are covered and uncovered too rapidly. But there are bare spots not protected by grass where coarse sand and gravel are driven back and forth by the wind, and here the carved bowlders can be seen in considerable numbers and in all stages of the process. In some cases it appeared probable that these bare places were where drifting sand had swept over the surface and the till had been partially denuded by the wind in the manner before described. It now became evident why one face of the Bethel bowlders is in most cases unpolished. That rough face was the under surface, and was protected from the attrition. If a bowlder, after having its exposed faces polished, was rolled over by the up-turning of a tree or by any other cause, the other face or faces became polished also. Where a bowlder lay deep in the ground only a small part at the top could be polished. If it lay on the surface evidently every face except the bottom could be carved simultaneously, provided it was not too large. Large bowlders are only carved laterally; their tops, being above most of the flying sand and gravel, weather faster than the progress of the attrition. The freshness of surface noted by Dr. True is due to the fact that the process is recent. Indeed every feature of the Bethel bowlders under consideration is fully accounted for by the hypothesis of sand-sculpturing under the action of the wind. An accessible locality for observing the process of sand-carving now in operation is found about one mile from West Bethel on the east side of the road leading to Mason. The fields around Bethel village have so generally been plowed that one finds it hard to determine their original condition.

U. S. Geological Survey, October, 1885.

ART. XIV.—*The Westward Extension of Rocks of Lower Helderberg Age in New York;* by S. G. WILLIAMS.

IN a paper published in this Journal, September, 1885, it was shown that the extensive plaster beds of Cayuga County, near Union Springs, are associated with limestones both above and below them, containing fossils of the Water-lime Group and of some of the lower stages of the Lower Helderberg, like *Eurypterus remipes*, *Leperditia alta*, *Nucleospira ventricosa*, *Meristella bisulcata* and *Spirifera Vanuxemi*, and hence it was inferred that their geological position is as high as the summit of the Water-lime Group, rather than in the Salina, as they have heretofore been thought to be.

I wish now to return to the subject to show that the Lower Helderberg period, including all above the Water-lime Group, is represented at least as far west as Cayuga Lake, by limestones not less than sixty-five feet in thickness, containing an unmistakable Lower Helderberg fauna; as well as to compare with this series of rocks the results of some examination of strata of similar geological position on the outlet of Skaneateles Lake and at Oriskany Falls.

The rock series in Cayuga County which is interposed between the gypsum beds and the Oriskany sandstone consists of from sixty-five to seventy feet of impure limestones, partly of a drab color, and partly blue which mostly weather drab. Fossils are quite rare in these rocks, and from this fact, coupled with their usual drab color on weathering, and their proximity to the plaster beds which were assigned to the Salina period, they have hitherto been thought to belong to the Water-lime Group, while the Lower Helderberg proper has been thought to be unrepresented west of Oneida County. Thus Vanuxem, p. 123 of his Report on the 3d District of New York, says that the immediate associates of the Oriskany sandstone cease before reaching Cayuga Lake, and that the Oriskany rests on the Manlius Water-lime; and Professor Hall says, Paleontology of New York, vol. iii, p. 37, that the Lower Helderberg, from which he excludes the Water-lime, making the Tentaculite its base, is scarcely known west of Oneida County. In the final reports of the 3d and 4th districts, however, the Tentaculite limestone is included in the Water-lime Group, the fossils which are figured as belonging to it are chiefly those which characterize the Tentaculite limestone, and several of these are mentioned by Prof. Hall as occurring at a single locality in Ontario County.

Now rare as fossils are in the strata under consideration in Cayuga County, careful search has brought to light a number

of moderately fossiliferous localities in which have already been found at least fifteen species of fossils, two or three of which are probably undescribed, though showing apparent Lower Helderberg affinities, while the remainder all belong to the lower members of the Lower Helderberg, and not one has yet been found which is distinctive of the Water-lime. *Leperditia alta*, which occurs somewhat frequently in the beds below the gypsum in close proximity to *Eurypterus*, has not yet been found above. *Spirifera Vanuxemi*, which with *Leperditia alta* is so abundant in the Tentaculite limestone of Schoharie County, and which occurs in like association in the Lower Helderberg rocks at Put-in-Bay, Ohio, has been found well-preserved about eight feet above the gypsum, at the only point where it has been laid open with a roof of rocks; and traces of it have also been found at some other stations, one of which, though a somewhat doubtful occurrence, is only about ten feet below the Oriskany sandstone. *Strophodonta varistriata* and *Rhynchonella semiplicata* are tolerably abundant at two or three localities; *Strophodonta planulata?* occurs in a blue stratum not far below the Oriskany, associated with an aviculoid shell probably *Megambonia aviculoidea;* and the lamellibranch which is described as *Anatina? sinuata* in vol. iii of New York Palæontology, is found more abundantly and better preserved in a bluish limestone near the base of the series than as yet it has been discovered elsewhere. The most abundant fossil is *Stromatopora*, which is found near the base of the series and at its very summit, and at two localities a half mile distant from each other forms a large part of a stratum nearly four feet thick. With it is associated occasionally *Favosites Helderbergiæ* and a species of Zaphrentis. Besides these fossils, *Nucleospira ventricosa* and *Meristella lævis* occur very sparingly, the former having been found at a single locality, and a small form of the latter at two; and there are also, besides undeterminable impressions of a medium-sized Rhynchonella, a Lingula, a large Platyceras, and a branching fucoid which seems to be undescribed, as also a curious fragment which may possibly prove to be a longitudinally fluted Orthoceras. Sparing as are the fossils of these rocks, it may easily be seen that they are all Lower Helderberg forms which prevail chiefly in the Tentaculite and Lower Pentamerus divisions, with a few somewhat doubtful forms of the Delthyris Shaly Lime. Professor James Hall, who recently made a brief examination of this series of fossils, recognized their character as distinctively Lower Helderberg. There are however no indications of the subdivisions which make so striking a figure in the eastern part of the State; nor could these be expected amid such general uniformity of lithological character as here prevails. It is of interest never-

ss, to learn that the circumstances which favored the depo-
ı of a series of limestones of diverse physical characters
a rich and varied fauna in Eastern New York during the
:r Helderberg period, were not wholly interrupted farther
vard, as has been supposed, at the close of the Water-
epoch; but continued in a modified form and under sim-
and more uniform conditions possibly to its very close,
:ed by the prevalence only of a few of the hardier and
persistent forms of life.

ıe limestones which underlie the Oriskany sandstone on the
t of Skaneateles Lake, about fifteen miles east of the region
lescribed show an exposure so far as they are laid open by
ries, of thirty-five feet, but Mr. E. B. Knapp, a careful local
ɔgist, judges their entire thickness to be more than double
Any attempts at inferring the thickness of these beds with-
ıctual measurement is, however, liable to errors, since the
disturbances which were noted in my paper on the age of
;ypsum deposits as affecting the corresponding strata on
ıga Lake, occur here also, the extensive quarries revealing a
linal bend of a few degrees dip, and with an east and west
e. The beds which admit of definite measurement consist, in
ıding order, of nine feet of bluish limestone well supplied
Strophodonta varistriata and *Spirifera Vanuxemi*; from ten
even feet of dark drab beds in three seams which are
ly burned for hydraulic lime; three feet and a half of blue
stone which is highly esteemed for quicklime; and twelve
of blue limestone of highly variable and often siliceous
ıcter. Immediately beneath the Oriskany sandstone the
:r member of the series is replete with *Stromatopora* and
rdita alta, and contains besides, *Spirorbis laxus*, somewhat
dant and beautifully preserved *Holopea* (*Littorina*) *antiqua*,
occasional *Favosites Helderbergiæ*. I have observed also
these a single example of *Spirifera Vanuxemi*, although
Knapp assures me that it rarely occurs above the Hydraulic
. The small series of fossils here enumerated, as well those
ailing below the hydraulic beds as those which are found
e, certainly indicates the horizon of the Tentaculite Lime-
: as it occurs in the eastern part of the State; and the sim-
y to that group is strengthened by the occurrence at its
nit of a bed of Stromatopora, recalling the "thin mass of
stone consisting almost entirely of the coral Stromatopora,
constituting a very persistent member of the group,"
h Professor Hall gives, p. 37, vol iii, of New York Paleon-
;y, as the uppermost member of this limestone in the east.
:ther however this fact indicates that strata synchronous
the higher members of the Lower Helderberg series were
r deposited in this region, where the limestones are suc-

ceeded regularly by the Oriskany sandstone without any visible indications of an intervening land condition; or whether it may be interpreted as due to the persistence of species which alone were adapted to the conditions of existence here presented, is a question to which it is not easy to give a definite answer. The fact that several species indicating higher horizons are intermingled with some of these on Cayuga Lake, and that two of the Skaneateles species occur with a few others in apparently correspondent strata still farther westward in Ontario County (Report on 4th District, p. 141) may possibly give some support to the latter hypothesis; as may also the occurrence of *S. Vanuxemi* and *Tentaculites gyracanthus* high up in the thick Lower Helderberg series of Pennsylvania. (Report, F^2, pp. 61 and 182.)

The exposure of Lower Helderberg rocks at Oriskany Falls, eighteen miles south of Utica, is interesting, partly because it is so laid open by deep and extensive quarries as to give nearly a complete section of about 120 feet of rocks, 115 feet of which can be definitely measured from the Oriskany sandstone, here ten feet thick, down to the bank of the abandoned Chenango canal; and partly because, while highly fossiliferous at several levels, it shows the condition and tendencies of the Lower Helderberg limestones at a point nearly midway between Schoharie County and Cayuga Lake. The uppermost twenty-five feet of limestones at this locality which are largely covered by soil, where they are revealed at top and bottom, are shown to be a gray, sub-crystalline rock which, where it can be reached immediately beneath the Oriskany, is replete with *Merista arcuata* and an occasional *Strophodonta radiata*. At the base of this series of gray beds is a remarkable seam, about a foot thick, filled with *Pentamerus galeatus* and *P. Verneuilli*, *Rhynchonella mutabilis* and *R. altiplicata*, *Atrypa reticularis*, *Orthis concinna*, *Strophodonta varistriata*, *S. punctulifera* and *S. planulata*, and occasionally *Spirifera Saffordi* and several other species, the same fossils being also somewhat abundant in the three to four feet above this seam which are opened by the quarries. Indeed the difficulty in establishing any divisions like those farther eastward, is not, as Professor Vanuxem found it here forty-five years ago, from a scarcity of fossils, but from the complete intermingling of Lower Pentamerus and Shaly Lime species, both in these beds and in the limestones for fully forty feet below them. Just beneath the Oriskany indeed, at the single point where it could be conveniently reached, I found only the two Shaly Lime species that have been named; but it is quite possible that this is merely a casual occurrence, and that were these beds as thoroughly opened as those below, the same intermingling of species would be found to hold good.

: gray beds are also, as Vanuxem remarked, dissimilar in :al character to the Shaly Lime of Schoharie County, ,hough gray and somewhat crystalline, bear no great re- ance to the rough Pentamerus limestones of the eastern ties.

ow these gray beds, the limestones for about ninety feet ' a prevailing blue color, and, with an exception presently mentioned, are so pure as to be very largely quarried for ɔurning and for a flux in the iron furnaces a few miles near Clinton. For twenty-nine feet below the gray beds, blue limestones show but few fossils save *Favosites Helder-* : and *Stromatopora* which are tolerably abundant. Below occur about seven feet of impure, slightly magnesian, sh beds, often highly laminated and occasionally present- ›eautiful ripple-marks, testifying to a considerable tempo- change in the conditions of deposition. The impurities ese beds, amounting to 20 per cent of insoluble matter y siliceous, render them unfit for lime-burning, and they sed for building stone. Though not remarkably rich in s, many of the slabs show fine large *pygidia* of *Dalmania ɔptyx* and occasional *Discina discus*, and I observed one slab which, besides several individuals each of these two ɜs, had also a beautiful *Conularia* unlike those described in ii, Paleontology of New York. *Dalmania pleuroptyx* con- s for several feet below the building stone beds, from ı point downward for about forty-five feet few fossils are save *Stromatopora*, *Favosites Helderbergiæ*, *Strophodonta riata*, and rarely *Spirifera Vanuxemi*. *Euomphalus sinu-* ıas also been given me as from these beds. Near the base e 115 feet of strata which I measured, *Stromatopora* is l very abundantly associated with *S. varistriata* in thin- ɜd limestones. In beds a little below my measured sec- reached by going northward along the banks of the aban- l canal, since its waters flow northward while the strata p gently south, *Spirifera Vanuxemi* and *Leperditia alta* are l in great abundance with a few *Spirorbis laxus* and *:tes fructicosus*, while an occasional thin layer abounds in 'entaculite which occurs in such myriads at a like horizon : eastern localities.

e lower strata of the series for nearly fifty feet contain, fore, apparently only fossils which are found commonly e Tentaculite limestone, and they doubtless correspond with that stage. Possibly also the very uppermost beds, e as they are in physical character to the Shaly Limestone ɜ eastern counties, may be parallel with that horizon; but the complete intermingling of forms characterizing the r Pentamerus and the Shaly Limestone in fully fifty feet

of strata, including at least a portion of the gray beds, it does not seem possible to separate these groups definitely, while nothing answering to the Upper Pentamerus occurs here.

This description of the Lower Helderberg at Oriskany Falls has been given to call attention to the fact that a series which in Schoharie and Albany Counties presents four strongly marked changes in rock characters, accompanied by considerable differences in the grouping of specific forms, has here, with some apparent diminution of total thickness, become of much more uniform lithological character, even the gray limestones which crown the series lacking that massive and rough-weathering appearance which is so prominent at the east; and that this simplification of rock characters is accompanied by a tendency to obliteration of any definite divisions characterized by distinctive groups of fossils, the Tentaculite limestone horizon only being here clearly marked, and showing a tendency to retain its dominant life characters after the individuality of the other divisions has been lost by the blending of their faunas. In the Skaneateles section, as has already been seen, the life of the Tentaculite Lime only is represented, with the exception of *Favosites Helderbergiæ*, and the beds worked for hydraulic lime occur near the summit of the series; while on Cayuga Lake the seventy feet of limestones to which the Lower Helderberg, exclusive of the Water-lime, is there reduced, have all subdivisions quite obliterated, contain Stromatopora at two different levels and probably at three, and, while retaining two or three common fossils of the Tentaculite, vindicate their right to represent a large portion if not the whole of the Lower Helderberg period by containing a considerable number of its characteristic forms, including *Platyceras*, unmixed with any Water-lime species, as well as by lying above strata holding *Eurypterus* and *Leperditia alta*.

It may be remarked that the three sections that have here been given, as well as the widely-known series in Schoharie County with which they have been compared, all have well-developed Oriskany sandstone to mark their upper limit, showing the probability that all are equally complete as they were deposited, and if so, that all are probably synchronous since they are all equally free from any indications of having been withdrawn from deposition by becoming land areas. If this be true, their differences both of lithology and life must be due to differences in circumstances of deposition in different portions of the same long Silurian coast-line. Indeed, when it is considered that the Onondaga Salt series, which is very thick in Ontario and in Western and Central New York, thins out entirely in the east: that the non-saliferous representative of the Onondaga (Salina) in Pennsylvania has, in a portion of its

ctent, many interstratifications of limestones in the upper two-thirds of its thickness, and where thickest in Perry County, ontains the Lower Helderberg forms, *Leperditia alta* and *Beychia notata*, low down in the series, while according to Prof. aypole it is not definitely separable from the Lower Helder- rg above (Pennsylvania Reports, F², G⁶ and G⁷); and that e Lower Helderberg which is very thin in Ohio, Ontario and estern New York, thickens eastward, shows its distinctive e characters on Cayuga Lake, and attains its fullest and most versified development in eastern New York, where the salif- ous series has quite died out. It seems not impossible that ese two formations, usually considered distinct, may have een to a large extent simultaneously deposited, the one in ngthened basins near the sea border, which when filled with eir peculiar accumulations, gave place to sea-shore deposits f limestones, often impure, as in the west; the other, in open aters which, at first contaminated with mechanical sediments, ter became clear, and in which, from oscillations of level affect- ıg chiefly its eastern areas, limestones of varied characters ere accumulated whose western extension had little variabil- y. Under such circumstances, it would not be difficult to onceive why the Lower Helderberg should thin to the west- ard where the Salina appears in greatest volume, nor why it hould there be represented by impure limestones, resembling he lowest portion of the eastern series, while more nearly ynchronous with its higher portions. It would also be nat- ıral to expect, in this case, that the fauna of the western strata vould consist of forms migrating from the east, and, on this ccount, partaking largely of the life characters of the lower astern deposits, since such migrations are likely to take place ery slowly.

ART. XV.—*Meteoric Iron from Jenny's Creek, Wayne County, West Virginia;* by GEORGE F. KUNZ.

[Read at New York Academy of Sciences, Nov. 30, 1885.]

DURING the early part of last April a 9-ounce piece of min- al, supposed to be silver, was sent to Dr. H. G. Torrey for etermination, by Major Delafield Du Bois, of Charleston, West irginia. Dr. Torrey found it on examination to be an iron of eteoric origin, and kindly loaned it to me for description. he piece delivered to me was supposed to be all of the fall, ıd on this supposition it was described as the Charleston, anawa County, West Va., meteorite, in a paper read at the nn Arbor meeting of the American Association. Through the

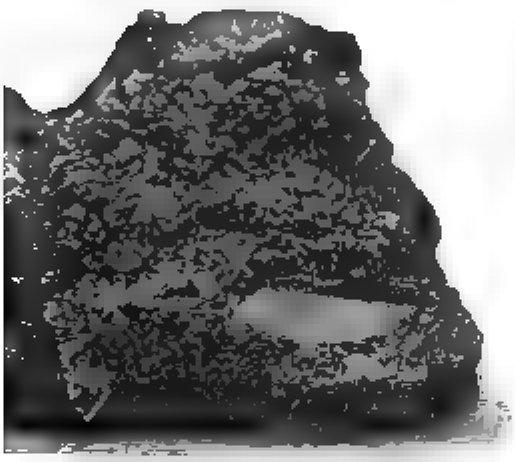
kindness of Major Du Bois, Mr. J. F. Hoard and Dr. J Tilden, who went to considerable trouble in ascertainii am able to announce the true locality.

Mr. Hoard writes that the iron was found on land bel to Maston Christian, situated on the "Old Fork" of J Creek, a tributary of the "Tug Fork" of Big Sandy (Tug Fork being the boundary line between West V and Kentucky), in the upper end of Wayne County. pieces were all found in the creek bed, i. e. the ravine or through which the creek flows. The first piece, we probably two or three pounds, was found by Christian' sometime earlier than the spring of 1883. It was suppo be simply a rich "kidney" of limonite, and was soon los of. In the spring of 1883, however, a second piece was by Christian himself while drifting staves in the creek. piece, which weighed about twenty-three pounds, create siderable excitement and speculation. It is even stated shrewd speculator, who had in his possession a lump metal, had realized largely by burying it on different digging it up again, and then selling the pieces of pr successively as being silver-bearing. The rumor was c that the vein was from nine to sixteen inches thick. broken up and distributed among several parties interested find, and as it was friable, much of it was lost in this m About the first of December, 1885, a third fragment was up by Mr. Christian in a pool of still water, only about fift twenty feet from where he had found the other. It weigl grams (about seventeen ounces), is all broken except or which is altered to limonite and has no visible trace of tered crust. Its measurements are 88^{mm}, 57^{mm}, and 46^{mm}. total amount found thus far in the three pieces is prc twenty-six or twenty-seven pounds. Both of these latter were found in water and had a coating of rust or earthy ter similar to that found on "kidneys" of ore, whicl removed easily with the hands or by washing.

The iron is octahedral and made up of crystalline l of plessite and kamacite, irregular in shape, brittle, h rounded ends and cleaving readily. Between these ar thin, springy and flexible folia or plates of schreibersite, of which are 6 or 8^{mm} square. The latter mineral wa observed in two other small pieces sent to me. Troilit also observed in these. The original weight of the piece l me for description was 275 grams; one small slice of grams weight had been removed to show the internal stru so that the larger piece, fig. 3, now weighs 228·2 grams. three cuts show the exact size of these pieces, and the i ngs on the etched surface as well as the octahedral stru

ıe exterior of the iron have been accurately reproduced ›hotography direct from the iron. (Original size as fol- : length, 66^{mm}; width, $40{\cdot}5^{mm}$; height, $33{\cdot}5^{mm}$.) The ι date of the fall of this iron is not known, and the surface

1.



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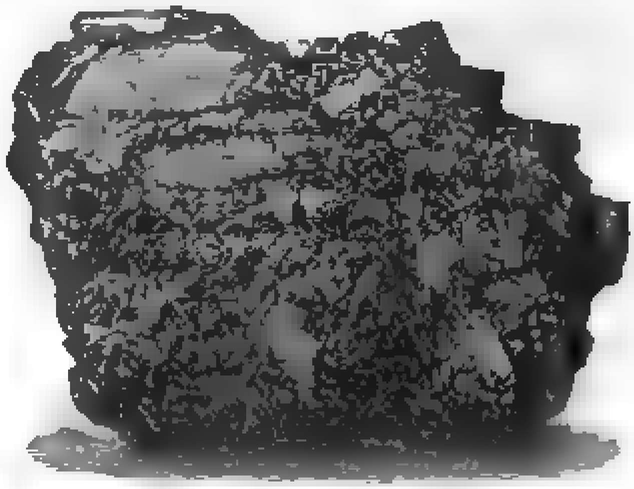
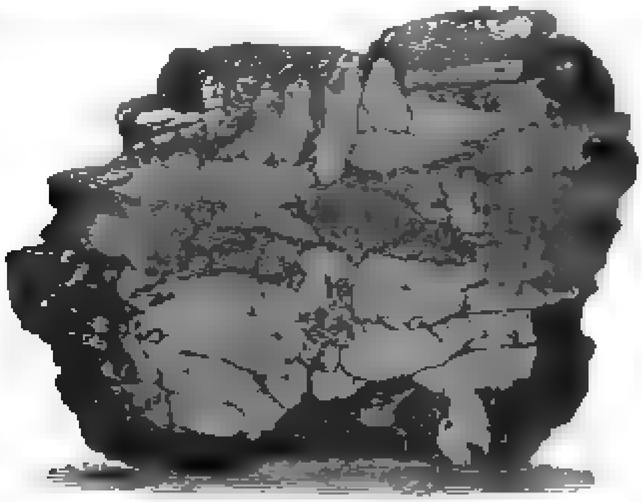


3.



'e not cracked off is altered to limonite to a depth of 2^{mm}. :longs to the "grobe Lamellen" of the new classification of A. Brezina. The Sevier County, Tenn., and the Arva ; nearest approach it in structure. The following analysis kindly made by Mr. J. B. Mackintosh, E.M., of the ol of Mines, New York:—

Iron	91·56
Phosphorus	0·13
Nickel and cobalt (by difference)	8·31
	100·00

ıe specific gravity of the figured mass is 7·344. The iron not show any Widmannstätten figures, the crystalline ture being really brought out in relief by the schreibersite ɔen the crystalline surfaces of the iron.

ıce this iron was broken and scattered in small pieces, we expect to see them turn up as a number of different falls.

but the coarsely crystalline structure, and the broken appearance of the pieces which are characteristic of this fall, will at once identify them.

The late Judge M. J. Ferguson, while residing at Louisa, Ky., communicated to Mr. S. Floyd Hoard, that one summer about five years ago, at about 1 A. M., he witnessed a meteor of wonderful brilliancy falling in the direction of the spot where these fragments have since been found; and that he predicted at the time that one would probably be found in that vicinity. The windows facing that way were open, and the curtains drawn back. The light was as brilliant as noonday, and of sufficient duration for him to step to the window and see the meteorite fall, as he thought a short distance away, and surely within the limits of Wayne County.

There is, therefore, a strong probablity that the pieces now being described are fragments of the identical meteorite which startled Judge Ferguson on that night. The fact that these masses of meteoric iron were found in water, and that all the branches of the creeks in this county are subject to strong floods of a few hours' duration, but while they last, sufficient to float logs, may account for the finding of these three pieces (evidently fragments of one piece of very friable iron), scattered as they were, and also for the oxidation of the crust of the iron, which might have remained intact for a much longer period, had the meteorite buried itself in the earth. Of the twenty-six or twenty-seven pounds which were found, only about two pounds have been preserved. I am under obligations to Major Delafield Du Bois, S. Floyd Hoard, and Dr. John N. Tilden, for obtaining information and material.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *On the Separation of Liquefied Atmospheric Air into two layers.*—In his first paper on the liquefaction of air, Wroblewski noted the fact that the phenomena observed were not those of a simple gas, but resembled more nearly those of a mixture, the components of which had different laws of liquefaction. The critical point so-called, of air for example, arises only from the fact that the tension-curves for oxygen and nitrogen agree so closely; the pressure lying between 37 and 41·3 atmospheres, and the temperature between $-140°{\cdot}8$ and $-143°$. In the present paper the author shows that when air is liquefied under high pressure and then exposed to a pressure of only one atmosphere, the oil ing point rises gradually from $-191{\cdot}4°$ to $-187°$, owing to a

hange in the composition of the liquid, the nitrogen evaporating ore rapidly than the oxygen and the boiling point approaching at of oxygen, —181·5°. When evaporated in oxygen, the ten-n steadily diminishes and the temperature passes through a ries of maxima and minima. But more than this. The liquefied · may separate into two distinct layers differing in appearance d in composition and defined by a sharp meniscus. To obtain is separation, a certain quantity of air is liquefied at —142°, and seous air allowed to enter into the tube until the pressure is 40 m. and its optical density is equal to that of the liquid, the eniscus entirely disappearing. The pressure is then slowly re-aced, and when it reaches 37·6 atmospheres, a new meniscus rms at a point in the tube much higher than the place previously ccupied by the vanished meniscus. Presently the former menis-us reappears in its old position and two liquids are distinctly seen uperposed. In some seconds bubbles form at the lower meniscus, endering the upper liquid opaque and ultimately destroying the lividing meniscus and leaving a homogeneous liquid. By the in-troduction of a small metal pipette the author has removed por-tions both of the upper and of the lower layer and has analyzed them. The lower liquid contained 21·28 to 21·5 of oxygen, the upper one 17·3 to 18·7. This experiment clearly shows that the disappearance of the meniscus of a liquid when it is obtained by increasing the pressure exerted by a gas on a superposed liquid, does not effect a solution of the liquid in the gas.—*C. R.*, ci, 635, Sept. 1885; *Phil. Mag.*, V, xx, 463, Nov. 1885. G. F. B.

2. *On the Velocity of the Explosive wave in Liquid and Solid Detonants.*—BERTHELOT has supplemented his researches on the velocity of propagation of the wave of exploding gases, by a simi-lar series of investigations on the velocity of the explosive wave in detonating solids and liquids. For this purpose the explosive was placed in a tube of block tin or lead, or an alloy of the two, one to two millimeters in interior diameter and of varying length up to 100 or 200 meters. It was distributed as uniformly as pos-sible, and in some cases compressed in the tube. The explosives used were gun cotton, both in the ordinary form and granulated, nitro-starch, nitro-mannite, dynamite, nitroglycerin and panclas-tite. Most of the measurements were made on Sébert's velocime-ter, though a fall-chronograph and a Le Boulengé chronograph were also used. At the ends and at 25 meter intervals, the tube containing the explosive was surrounded by fine conducting wires leading to the registering electro-magnets. These wires being successively ruptured by the explosion, the order of the phenome-non was registered on a smoked surface, simultaneously with the vibrations of a tuning fork of known rate. A single experiment, made on the 27 Sept., 1882, will show the method of operating. Tubes 6 mm. interior and 10 mm. exterior diameter, were filled with nitroglycerin. The progress of the wave of explosion was registered on a Le Boulengé chronograph by the breaking of the copper wires attached to the tube. The explosion was effected by

means of 1·5 grams fulminate in one end of the tube. In the first trial the tube used was 14·46 meters long between the interrupters, the first of these being placed 4 cm. behind the detonator, and the second 4 cm. from the other end. The time required for the wave to travel through the tube was 0·013980 second; which gives 1034·4 meters as the velocity of the explosive wave. In a second trial, in which the tube was 11·77 meters long, the time was 0·011491 second; giving a velocity of 1024·3 meters. The results show that the velocity is affected by the compactness of the charge, the size of the tube and even by the material of which it is made. With ordinary gun-cotton for example, experiments made in 1884 show that in lead tubes 4 mm. external diameter, the density of the charge being from 1 to 1·2, the mean velocity for lengths of 100 meters varied from 4952 to 5500 meters per second, and for successive intervals of 25 meters, from 4671 to 5980 meters per second. In tubes of tin, the density of charge being 1·2, the velocity was from 5736 to 6136 meters per second in tubes 4 mm. external diameter, and 5845 to 6672 meters for those of 5·5 mm. diameter. For gun cotton from hydrocellulose, the mean velocity in tin tubes of 4 mm. diameter was 5916 meters, and in those of 5·5 mm. 6100 meters; the velocity in lead tubes 4 mm. diameter being 5200 meters. With granulated gun cotton densely charged, 1·17, in a 4 mm. tube, a velocity of 4770 meters was obtained. In lead tubes 5·5 mm. external diameter, the density of the charge being 1·27, the mean velocity was 5406 meters. With a less density of charge, 0·67 to 0·73, in lead tubes 8·44 to 10·6 mm. external diameter, the mean velocity varied from 3767 to 3795 meters. With nitro-starch, in a tin tube 4 mm. diameter, the density being 1·2, the velocity varied from 5222 to 5674 meters, and in a tube 5·5 mm. 5816 meters. In a lead tube of 4 mm. the density being from 1·1 to 1·2, the velocity varied from 4886 to 5006 meters; rising to 5512 when the density was increased to 1·35. Nitromannite with a density of 1·5 gave a velocity of 6965 meters; with a density of 1·9, of 7705. Nitroglycerin could not be made to detonate in lead tubes smaller than 3 mm. internal diameter, unless the temperature was above 14°. Tubes of this size placed in the sun gave velocities of 1310, 1015 and 1286 meters. Dynamite in Britannia tubes 3 mm. internal diameter, gave a velocity of 2333 to 2753 meters. In lead or Britannia tubes 6 mm. interior diameter from 1916 to 3180 meters; the mean of all being 2668 meters. Panclastite (equal volumes of petroleum of gravity 0·710 and hyponitric acid) in a tube of tin 5 mm. in diameter and 25 meters long, gave unsatisfactory results. By using equal volumes carbon disulphide and hyponitric acid, in a lead tube 3 mm. in diameter, a velocity of 4685 meters was obtained in one experiment and 6658 meters in another.—*Ann. Chim. Phys.*, VI, vi, 556, Dec. 1885. G. F. B.

3. *On the Visible representation of the Ultra-red Rays.*—In the well known experiments of Tyndall on Calorescence, the focus of the ultra-red rays, obtained by means of an absorption cell filled

with a solution of iodine in carbon disulphide, is made evident by the incandescence of a platinum plate. LOMMEL suggests the use of phosphorescent substances to render this focus visible. Balmain's luminous paint answers the purpose; but the author prefers a greenish-blue phosphorescent calcium sulphide. When this has been made slightly phosphorescent by ordinary daylight, it is increased to a bright luminosity by the less refrangible, especially the ultra-red, rays. When the radiation is moderately strong, this luminosity lasts for hours and is visible for some time even after the radiation ceases. Then a dark spot takes the place of the bright one, the luminous power having been diminished or entirely destroyed in consequence of the increased emission. If the powder be placed between two plates of glass, the ultra-red portion of the spectrum produces a greenish-blue phosphorescence visible on both sides of the glass. If the dark focus be received on this screen, it appears as a bright spot on a feebly luminous ground, which changes into a black spot after some time, looking as if a hole had been made through the luminous surface. The author suggests the use of a solution of nigrosin in chloroform or alcohol in place of the iodine in carbon disulphide employed by Tyndall, for filtering out the luminous rays. The nigrosin transmits only ultra-red rays. Since these rays are considerably absorbed by alcohol the solution in this menstruum answers well for the above described experiment, since the phosphorescent luminosity lasts longer. The solution in chloroform is much more diathermanous and answers well for showing the thermal effects at the focus. So sensitive are these phosphorescent substances to the ultra-red rays, that the flame of gas, of a lamp or even of a candle may be made to show the phenomenon. Using a lens and a cell filled with the black liquid, a sharp bright image appears on the screen, which gradually diminishes and finally changes into a dark image on a brighter ground.—*Wied. Ann.*, II, xxvi, 157, 1885; *Phil. Mag.*, V, xx, 547, Dec. 1885. G. F. B.

4. *Improved method of preparing Nitrogen dioxide.*—KAEMMERER has suggested an improved method of preparing nitrogen dioxide by which a much steadier flow of this gas is secured. The apparatus consists of a two-necked Woulfe's bottle, having a dropping funnel in one of the openings and an evolution tube suitable for washing or drying the gas in the other. The bottle is one-third filled with a saturated solution of sodium nitrate, and strips of copper are introduced. To evolve the gas, concentrated sulphuric acid is allowed to flow into the bottle more or less rapidly according to the quantity of gas desired. With a bottle of two liters capacity and a funnel-tube of 500 c. c., the yield of nitrogen dioxide gas may be maintained steady at the rate of a liter in five minutes.—*Ber. Berl. Chem. Ges.*, xviii, 3064, Dec. 1885. G. F. B.

5. *On the Action of Carbon monoxide and the vapor of Water at high Temperatures.*—NAUMANN and PISTOR have continued their researches on the phenomena attending the produc-

tion of water gas and have now studied the reaction which takes place at high temperatures between the vapor of water and carbon monoxide. The gases were passed through a glass tube containing a layer of pumice-fragments 80 cm. long. The carbon monoxide prepared from potassium ferrocyanide and sulphuric acid and purified from oxygen and carbon dioxide by phosphorus and potassium hydrate, passed through water heated to 80° on its way to the tube; thus giving a mixture of about equal molecules. The tube was heated in a combustion furnace, the temperature being determined by means of the melting of salts of known fusing points. In the first experiment, in which the temperature lay between the fusing point of silver iodide (530°) and pyrophosphate (585°) the evolved gas contained no carbon dioxide and after explosion with oxygen no indication of the presence of hydrogen; a result confirmed by a second experiment. In the third experiment, the temperature was carried to between 602° and 634°, and the evolved gas contained 1·5 per cent carbon dioxide and 3 per cent hydrogen. For higher temperatures, porcelain tubes were used 8 mm. diameter, heated in a Fletcher furnace. The carbon monoxide, carefully freed from the dioxide and oxygen was mixed with water vapor and in the fourth experiment passed into the tube, heated in the furnace to between 861° and 854°. On analyzing the issuing gas, 8 per cent of carbon dioxide was found present. In the fifth experiment, the tube was filled with pumice for a length of 25 cm. The gas evolved contained 10·6 per cent carbon dioxide. Since the silver spiral placed in the tube had melted and the copper spiral had not, the temperature reached must have been 954°. Hence it appears that no apparent reaction takes place between carbon monoxide and water vapor at 560°; that at 600° about 2 per cent, at 900° 8 per cent, and at 954° about 10·5 per cent of the monoxide is converted into dioxide. Thus the very conditions which oppose the action of hydrogen upon carbon dioxide, favor the action of water vapor upon carbon monoxide.—*Ber. Berl. Chem. Ges.*, xviii, 2894, Nov. 1885. G. F. B.

6. *On the Atomic weight of Cerium.*—Brauner has made an elaborate investigation of the cerium group of metals and now gives the results of his determinations of the atomic weight of cerium. For this purpose anhydrous cerous sulphate was employed, the atomic weight being calculated from the ceric oxide which this salt left on ignition. For the preparation of the sulphate, the crude oxides obtained from cerite were dissolved in nitric acid, the excess of acid removed by evaporation, the syrupy liquid slightly diluted and poured into a large quantity of pure boiling water. Almost the whole of the cerium present was precipitated as basic ceric nitrate. After washing this was dissolved in nitric acid and again precipitated with water; thus obtaining a series of fractions. To obtain the cerous sulphate, the ceric nitrate was dissolved in sulphuric mixed with sulphurous acid; the excess of acid evaporated, the heavy metals precipitated with

hydrogen sulphide, and finally a crystalline salt of the formula $Ce_2(SO_4)_3(H_2O)_8$ was thrown down by adding three times the volume of alcohol. A second precipitation gave perfectly neutral cerous sulphate. For final purification, the salt was dissolved in cold water, and the beaker containing it was plunged into boiling water. On stirring it a fine crystalline powder $Ce_2(SO_4)_3(H_2O)_6$ was thrown down which was collected for use. To dehydrate it, it was heated in the vapor of boiling sulphur; since at this temperature it loses its water entirely, but is not otherwise altered. For the analysis a weighed portion of the anhydrous cerous sulphate was placed in a double crucible and exposed for ten or fifteen minutes to the flame of gas fed with air by a Fletcher's injector. It was then cooled and weighed. The greatest care was taken in all the experimental work, of preparation as well as analysis; and is detailed in the memoir. The result of twenty-three determinations is given, the maximum atomic weight being 140·433 and the minimum 140·033, the mean value being 140·2210; thus harmonizing the periodic values of the group.—*J. Chem. Soc.*, xlvii, 879, Nov. 1885. G. F. B.

7. *On the Synthesis of Cocaine and its Homologues.*—By treating anhydrous ecgonin with benzoic oxide and methyl iodide for ten hours to 100° in a sealed tube, MERCK has produced cocaine. Substituting ethyl iodide, the same reaction gave him its ethyl-homologue, which crystallizes from alcohol in brilliant prisms fusing at 108°–109°. Platinum chloride produces even in very dilute solutions of its salts a yellow precipitate soluble in hot water and crystallizing on cooling in brilliant yellow rhombic plates. Ladenburg proposes for it the name cocethyline.—*Ber. Berl. Chem. Ges.*, xviii, 2952, Nov. 1885. G. F. B.

8. *Electrostatic Battery.*—Mr. Damien having conducted investigations during a period of ten months upon single liquid batteries of various kinds, concludes that a cell formed of zinc and copper with the sulphate of magnesia is the best for electrostatic measurements. Instead of increasing the resistance of the cell by mixing the sulphate with plaster of Paris as in the Beetz cell, he puts in an outside resistance. With a resistance of 20,000 ohms in the circuit the cell remained constant even when short circuited. He finds that the electromotive force of this cell is very nearly constant, and is not sensibly affected by slight changes of temperature or by the concentration of the solution.—*Ann. de Chim. et de Phys.*, 16ᵉ série, t. vi, Nov. 1885. A. L. MC R.

9. *Handbook of technical Gas-Analysis;* by CLEMENS WINKLER; translated with a few additions, by GEORGE LUNZE. 125 pp. 8vo. London, 1885, (John Van Voorst).—The contributions of Dr. Winkler to technical gas-analysis have given him a foremost position among the writers upon this subject. This volume, though small in extent contains the practical instructions needed as well by teachers as by technical workers, and ought to be in the hands of all interested in the subject of which it treats. The name of the translator is a sufficient guarantee of the character of his part of the work.

10. *Alternating Currents of Electricity;* by THOMAS H. BLAKESLEY. 90 pp. 8vo. London, 1885.—This volume contains a series of papers, reprinted from the pages of the Electrician, discussing by the geometrical method alternating or harmonic currents of electricity.

II. GEOLOGY AND NATURAL HISTORY.

1. *Dr. Frazer's Report on the International Geological Congress.*—Dr. Frazer's Report published in the last volume of this Journal has had high commendation from the Secretary of the Congress.* In two points there were misunderstandings, and he has sent the following corrections.

(1.) Dr. Newberry corrects the last two words of the 18th line from the bottom of p. 469 in the last volume of this Journal from "no strict" to "a strong," thus making the sentence read . . . "and there is a strong line of demarcation between the Trias and the Permian." But he prefers to omit this line altogether. He sends the enclosed note of his remarks on this subject *in extenso.*

"In the discussion on the Permian, in North America, I said that 'In North America there is no strict line of demarcation between the *Permian* and *Coal-measures*, one shading into the other imperceptibly in stratification and fossils; there is no physical nor vital break, and while new forms come in toward the top of the series, such as *Monotis*, *Pleurophorus*, *Bakevellia*, etc., these are accompanied by some of the characteristic coal-measure species such as *Spirifer cameratus*, *Athyris subtilita*, *Productus semi-reticulatus*, etc. On the other hand, the most characteristic fossils of the Zechstein and Copper schists, plants (*Ullmannia*, *Voltzia*, *Walchia*, etc.), fishes (*Acrolepis*, *Pygopterus*) and mollusks (*Productus horridus*, etc.), have so far not been found in North America.' The Trias of the eastern half of North America represents the upper member of the European series, the Rhætic beds. [This is shown by the plants described by Emmons and Fontaine from North Carolina and Virginia, and those obtained from New Jersey and the Connecticut valley by the writer.†] Hence between our coal measures or the so-called Permo-Carboniferous or Permian and our Trias there is a great gap, a hiatus in our geological history, during which the Permian proper of Europe, at least the Zechstein and Copper schists, were perhaps deposited."

* M. Fontannes, the Secretary, in a letter to Dr. Frazer, dated Lyons, Jan. 3, 1885, says: "Je viens de lire, avec le plus grand soin, le rapport sur le Congrès de Berlin que vous avez eu l'amabilité de m' envoyer. Tous mes remerciments, et en même temps toutes mes félicitations pour l'exactitude rigoureuse de tous les détails. Il m'est impossible de comprendre comment, en l'absence de mes notes et de celles des stenographes, vous avez per rédigèr un travail aussi complet." * * *

† H. B. Geinitz: *Dyas* (1861-2). H. B. Geinitz: *Carbonformation in Nebraska* (1866). H. B. Geinitz: *Nachträge zur Dyas*, 1880-2). Wm. Fontaine: Older Mesozoic Floras of Virginia; Monograph VI., U. S., Geol. Survey. J. S. Newberry: Transactions N. Y. Academy of Sciences, vol. v, p. 18 (October, 1885.) .

(2.) Prof. de Lapparent, of Paris, answers a query as to an ap- rent contradiction between his theory and his argument: "It is ıe that the words, (page 468), make me say the contrary of ıat I said. I have maintained that the *same eruptions* which ok place during the Carboniferous epoch were maintained during ıe Permian epoch, of which the porphyries and melaphyres were ıe incontestable continuation of the porphyritic and trappean ɔcks of the Carboniferous; that in consequence, the Permian epoch as the termination of the '*Primary eruptions.*' I will add that page 467) ascribes to me a not very accurate opinion. I said hat the cephalopods of the deposits anterior to the Tertiary ter- anes furnished an excellent means of forming homogeneous groups; ut that this means only commenced to be easily applicable with he Trias. Nevertheless if one considers the *pelagic* Faunas of he Carboniferous and of the Permian, not only do they appear ntimately connected, but no one among those who are acquainted rith the pelagic Permian will ever be able to establish sub- livisions in it. Now, that which distinguishes *the systems* is that hey are groups susceptible of being sub-divided. The Permian hen, cannot form a system by itself. It cannot but be an *étage* in he great Permo-Carboniferous system."

2. *Cretaceous of Northwestern Canada.* — In a paper by Sir W. Dawson in the Canadian Record of Science, the subdivis- ons of the northwestern Canadian Cretaceous are given as fol- ows, beginning below. (1) *Lower Cretaceous* (Neocomian, etc.): a) The Kootanie series of the Rocky Mountains containing Cycads, Pines and Ferns; (*b*) the Suskwa River beds and Queen Charlotte Island coal series, containing Cycads, Pines and a few licotyledons. (2) *Middle* Cretaceous: (*a*) Mill Creek beds of Rocky Mountains containing dicotyledonous leaves similar to hose of the U. S. Dakota group; (*b*) Dunvegan series of Peace River with many dicotyledons, Cycads, etc. (3) Upper Cretace- us: (*a*) Coal-measures of Nanaimo, B. C., probably in this posi- ion with many dicotyledons, Palms, etc.; (*b*) Belly River beds, he Sequoia and Brasenia beds of S. Saskatchewan, Belly River, tc., with lignites; (*c* and *d*) Fort Pierre and Fox Hill series, narine; (*e*) Lower Laramie or St. Mary R. beds, the Lemna and Pistia beds of Bad Lands of 49th Parallel, Red Deer River, etc., rith Lignites. (4) Transition to Eocene: Upper Laramie or Porcupine Hill beds, the Platanus beds of Souris River and Cal- gary. These results are largely from the investigations of Dr. G. M. Dawson and the author. The latter has a memoir on the sub- ect in process of publication in the Transactions of the Royal Society of Canada.

3. *Journal and Proceedings of the Royal Society of New South Wales for* 1884, vol. xviii.—This volume contains, among its apers, brief notes on the development of Ceratodus and the Monotremes by Mr. W. H. Caldwell. The eggs of the Ceratodus were found in the waters of Burnett River in the early part of eptember. They were laid singly in the weeds and resembled hose of the common newt. They were fertilized in the water and

in this and other respects the development was much like that of the newt. Mr. W. E. Abbott discusses the subject of the water supply of the dry Interior plains of New South Wales. He speaks of this region as really a water shed, and of the amount of precipitation over this great water shed of Darling River as 30 inches a year in the mountains to the eastward and less than 10 inches to the westward. The plains are regarded as having been in comparatively recent geological time "covered by a sea," and as thus having derived its nearly level surface.—On the western side along the railroad it is 349 feet above the sea and 865 feet on the eastern, making the mean slope between about 2 feet a mile. The soil of two-thirds of the surface is a red clay with a slight admixture of fine sand without organisms, and of the rest, a grayish-black earth overlying the red along the water courses. Water is reached at a small depth; but five out of six of all wells sunk afford brackish water and there are many salt springs. The country is called the Salt bush country; the native plants have 30 to 43 per cent of the ash consisting of soda or sodium chloride. Gypsum nodules also are common, pointing, like the salt, to former marine conditions. The author supposes, with Mr. H. C. Russell of the Observatory, that the water of the River Darling becomes largely subterranean water and may be reached by artesian boring. But in view of the cost of such borings he recommends rather the construction of reservoirs for storing the surface water of the streams, and for collecting the water of rains on the slopes.

4. *Fossil Insects of the "Primary" (Paleozoic) rocks*, by CHARLES BRONGNIART. 20 pp. 8vo, with five plates (Bull. Soc. Sci. Nat., Rouen, 1885.—This valuable paper, illustrated by fine heliographic plates, reviews the facts with respect to Paleozoic insects and gives criticisms on the work of other authors. The discovery of the Carboniferous locality of Commentry, which since 1878, has furnished 1300 specimens of insects mostly "admirably preserved," gives great weight to his opinions.

5. *The Determination of Rock-forming Minerals*, by Dr. EUGEN HUSSAK; translated from the German by Dr. ERASTUS G. SMITH. 233 pp. 8vo, with 103 wood-cuts. New York, 1885, (J. Wiley & Sons).—The work by Dr. Hussak on the determination of the minerals which enter into the composition of rocks has been well received abroad, and now that it has been translated it will doubtless be as well known and appreciated among the English-reading public. The work gives, much more fully than has been attempted before in any single volume, the methods employed in the mineralogical study of rocks, optical, chemical and mechanical. A second part consists of tables for the determination of the rock-forming minerals; these give in condensed form a large amount of information about the individual species, which the student of microscopical petrography should make himself familiar with. The translation of such a work is a difficult matter and it is not strange that there are numerous points open to criticism. The reader will probably think that the translator has attempted to follow

he original almost too closely, and that a little more freedom would have sometimes made the rendering smoother and more readily intelligible. It would have been well too if the opportunity had been taken to correct occasional misstatements in the original.

6. *A "Manual of American Land Shells,"* by W. G. BINNEY. Bulletin No. 28 of the U. S. National Museum.—This work is an enlarged and revised edition of the "Land and Fresh-water Shells of North America, Part I," published by the Smithsonian Institution in 1869. Of its 528 pages the author devotes about fifty to the subjects of "geographical distribution, organs of generation, jaw and lingual dentition, and classification, 425 to the description of genera and species, and twenty-eight to a detailed catalogue of the Binney collection of land shells of North America, which Mr. Binney presented to the National Museum. The volume includes only the Geophila among the Pulmonata. The author accepts the division into families in Dr. Paul Fischer's recent work, but follows Alber's "Du Helicum," by Von Martens, in the Genera. The arrangement is not systematic, but according to geographical distribution. It is strange that at this day the author should have to regret the lack of data for determining satisfactorily this distribution. Thirteen species are stated to be universally distributed over the United States. Eleven foreign species occur on the sea-coast. *Limax maximus* is reported only from Newport, R. I., New York city and Philadelphia. We have found it abundantly in gardens in New Haven, Conn. A. G. D.

7. *Plasmolytic Studies.*—In 1884, Professor Hugo de Vries of Amsterdam published an account of a new method for determining the osmotic capacity of cells. It is well known that in dilute solutions of neutral salts the protoplasm of active healthy cells is little affected until after the lapse of considerable time, but that in stronger solutions of the same salts there is an immediate contraction of the protoplasmic contents, together with a separation of the mass from the walls at all points except where delicate threads still maintain their hold. By a long series of experiments, de Vries determined the strength of various salts by which this contractile action could be produced, and he ascertained also the effect in different cases upon the turgescence of the cell-wall itself. The same investigator has continued his observations and extended them into a contiguous field, namely, the behavior of the so-called vacuoles, or sap cavities of protoplasm, under the influence of the various contracting or plasmolytic agents. Reserving for a later issue an extended account of the whole paper, it may now be mentioned that he has discovered an interesting fact, susceptible of easy verification, that a minute trace of ammonia causes in every case a remarkable increase in the size of the vacuoles and completely changes their capacity for absorption. The bearing of this fact upon the curious observation of Darwin on the phenomena of "aggregation" appeared worthy of immediate attention. Hastily conducted observations with reference to this,

show that the light which de Vries has cast upon the phenom of vacuolar increase may explain many of the hitherto obs phenomena in the absorbing cells of insectivorous plants. I future number may be given some of the results to which h derived from de Vries's paper have led the present writer. G. L. G

8. *Histoire des principales Variétés et Espèces de Vignes d' gine Américaine qui résistent au Phylloxera;* par A. MILL DET.—If the wine-growers of France have been impoveris by the ravages of Phylloxera, certainly science has been enric by the numerous important works which have appeared in Fra relating to the means of checking the injury done by the t pests imported from America, the Phylloxera and the Peron pora of the vine. The previous important papers by Profes Millardet of Bordeaux on this subject are well known. In ext and abundance of new facts presented, the present work, a qua of 240 pages with 24 admirable lithographic plates, surpasses that he has hitherto attempted. The work originated in a mem presented to a committee of the French Academy in 1876, and present enlarged form is due in part to liberal private and pub subscription. The introduction treats of the histological a physiological conditions which favor the resisting powers different American species of *Vitis*. Of these, *V. rotundifoli rubra*, *cordifolia*, *rupestris*, *riparia*, *cinerea* and *æstivalis* are ab to resist the attacks of Phylloxera to a considerable extent, a are therefore available as stocks on which to graft in Fran while, on the other hand, in *V. candicans*, *Labrusca* and *Califo nica* the resisting power is small, although greater than in t European *V. vinifera*. The writer, following out the vie expressed in a previous paper, distinguishes between the gal produced on the smaller roots, which he calls nodosities, and tho on the larger roots, which he calls tuberosities, the former bein more dangerous. He considers that the destruction of the vi is not due primarily to the attack of the Phylloxera but to t growth of fungi which make their way into the roots through t nodosities whose surface becomes cracked and the interior spong

The main body of the work is divided into two parts. T first relates to the cultivated varieties, of whose origin, morph logical characters and resisting powers a very full account given. In his views with regard to the hybrid origin of some the varieties he not unfrequently differs from other writers. T second part gives a description of the wild species with their di tribution in North America. One can only praise the publ spirit of the French people, which leads them to encourage the publ cation of memoirs like the above, which, from their expensi character, could not be published by a writer at his own cost, an from which a publisher could expect no profit. W. G. F.

9. *Flora Brasiliensis.*—Fascicle 95, so soon following fasc. 9 gives proof that Dr. Eichler is prosecuting his great undertakin with vigor. This goes with the *Cucurbitaceæ* (issued in 1878 and some small orders to make up vol. vi, part iv. Fasc. 95 co

tains the *Campanulaceæ*, elaborated by Kanitz, along with the *Caprifoliaceæ*, *Valerianaceæ* and *Calyceraceæ* by C. A. Mueller of Berlin, altogether of little moment, and the *Asclepiadaceæ* by the late Dr. Fournier of Paris. The latter is an important order in the Brazilian empire, and is here amply illustrated by 51 plates. Brazil would appear to be particularly rich in genera, for fifty-six are characterized in the present work. Twenty-five of them are here founded by Fournier, eighteen of them on single species, five others have only two species each. There is one of six species (*Verlotia*), and one of four, but the latter is dismembered from *Gonolobus*. Dr. Fournier died in June, 1884, just when the printing of this monograph began, as a note by the editor informs us. The work therefore appears at a certain disadvantage. Probably many of the new genera may have to be reconsidered. A. G.

10. *Sketch of the Botanical Work of the Rev. Moses A. Curtis*; by Thomas F. Wood. pp. 10–31, 8vo. Raleigh, N. Car., 1885. —This pamphlet is stated to be an "Extract from the Journal of the Elisha Mitchell Scientific Society," and consists of a memoir "read before that Society at the University of North Carolina, May 22, 1885." It is pleasant to know that the University of North Carolina has such a Society, which commemorates its most distinguished scientific professor of former years, Professor Mitchell, who sacrificed his life to his zeal for investigation, on the high peak of the Black Mountain which bears his name, and where his ashes repose. Dr. Wood has in this essay erected a fitting and very interesting memorial of his old friend, the accomplished botanist, Mr. Curtis. It is full time that some such tribute to his memory was paid in his adopted State; and this will be read with interest and gratification by the few botanical companions of Mr. Curtis who still survive, and we hope also by a younger generation as well. It is illustrated by an excellent engraved portrait. A. G.

III. Miscellaneous Scientific Intelligence.

1. *The apparent position of the Zodiacal Light*; by Arthur Searle.—The inquiry here undertaken by Mr. Searle was entered upon with the hope of obtaining from the older observations suggestions with regard to the apparent position of the zodiacal light after correcting them roughly for the presumed effect of atmospheric absorption. Any suggestion thus attainable will lend additional interest to the work of future observers. The positive results are however of decided value. The principal conclusions are:—

1. It is probable that atmospheric absorption largely affects the apparent position of the zodiacal light.

2. After allowance for the effect of absorption, there is reason to think that the zodiacal light, as seen during the second half of the nineteenth century, has had a more northern latitude near the longitude 180° than near the longitude 0°.

3. Upon the meteoric theory of the zodiacal light, it is to be expected that a continous zodiacal band should be present; but the question of its actual visibility is complicated by the slight maxima of stellar density which are situated along those parts of the ecliptic most readily accessible to observation from stations in the northern hemisphere.

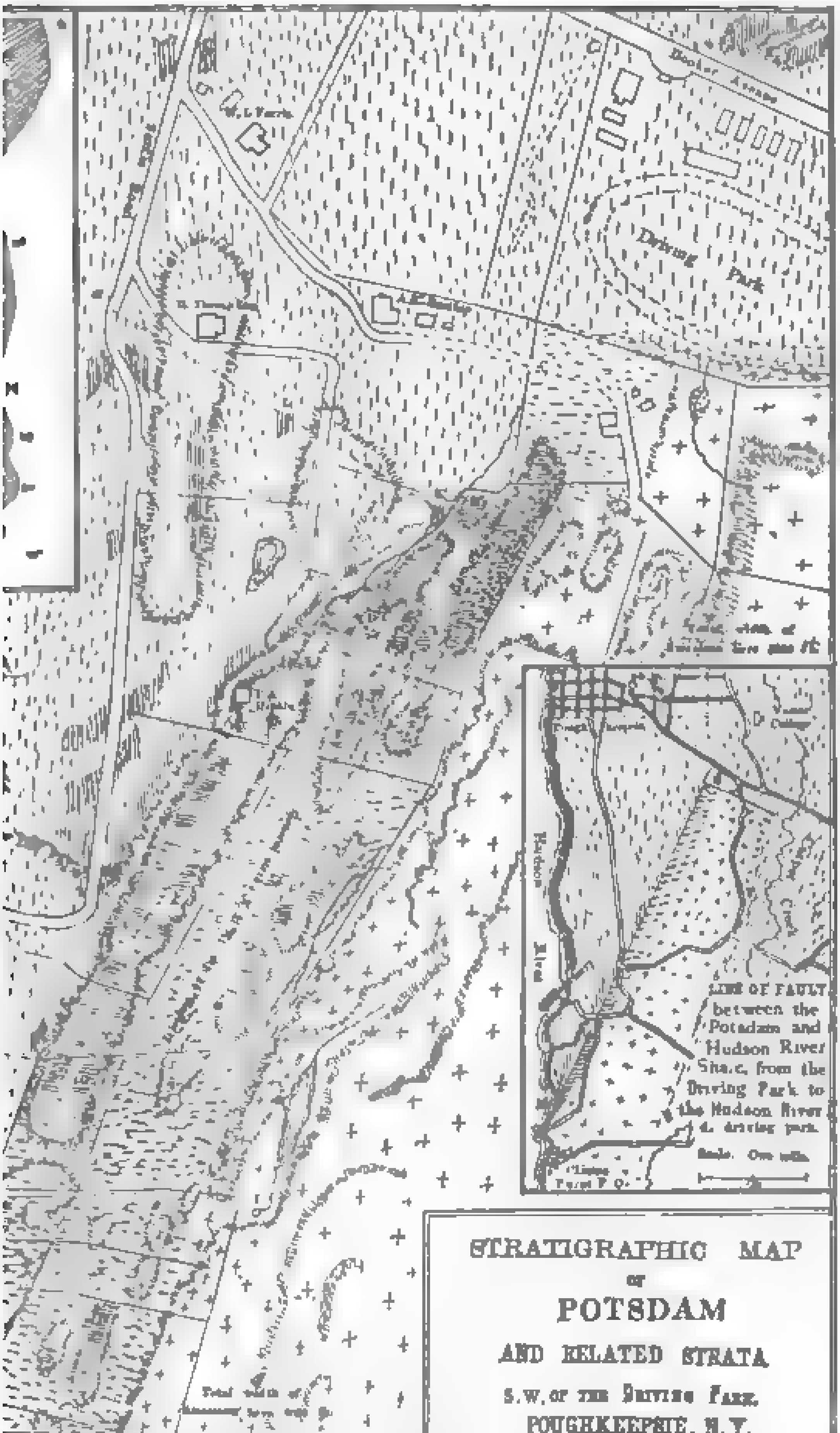
4. The belt of sky occupied by the projections of the orbits of the first 237 asteroids presents certain peculiarities which correspond to those of the zodiacal light, and suggest the hypothesis that the light may be partly due to minute objects circulating in orbits like those of the smaller planets.

Mr. Searle also finds incidentally that a stream of small stars is indicated by the Durchmusterung as extending along the ecliptic from ε Cancri to β Virginis. H. A. N.

2. "*International Exhibition of Implements against Cryptogams and Parasites.*"—The following circular has been issued by the Royal School of Viti-Culture and Œnology at Conegliano (near Venice). "The Minister of Agriculture, Industry and Commerce of Italy, in order to favor and facilitate the application of the methods of destroying the cryptogams and parasites of cultivated plants, and especially the use of the milk calx against the Perorospora (mildew) of the vine, has decreed (November 9th) the opening of an international Exhibition, and the offering of prizes for pumps, watering and pulverization implements. The Exhibition will take place at Conegliano at the Royal School of Viticulture and Œnology.

The following prizes will be awarded: 1 Gold Medal and 500 francs; 3 Silver Medals and, with each, 150 francs; 5 bronze Medals. The Ministry of Agriculture will also purchase rewarded implements to the value of 1000 francs for distribution to the Agrarian government stations and practical and special Agricultural schools.

Exhibitors must apply for admission to the 'Direzione della R. Scuola di Viticoltura ed Enologia in Conegliano,' not later than the 22d of February, 1886. The application must contain a short description of the instruments and the price of each object which is offered for exhibition. Italian and foreign inventors and makers, or their representatives, must present their machines at the model farm of the School at Conegliano by the 1st of March, 1886. On the 2d of March and following days will take place the trials and experiments for comparison, in which proprietors and viticulturists may assist. The jury that awards the prizes will present, within 20 days from the close of the exhibition, special reports about the exhibited instruments, which reports will be printed in the '*Bollettino di Notizie Agrarie*' of the Ministry of Agriculture."



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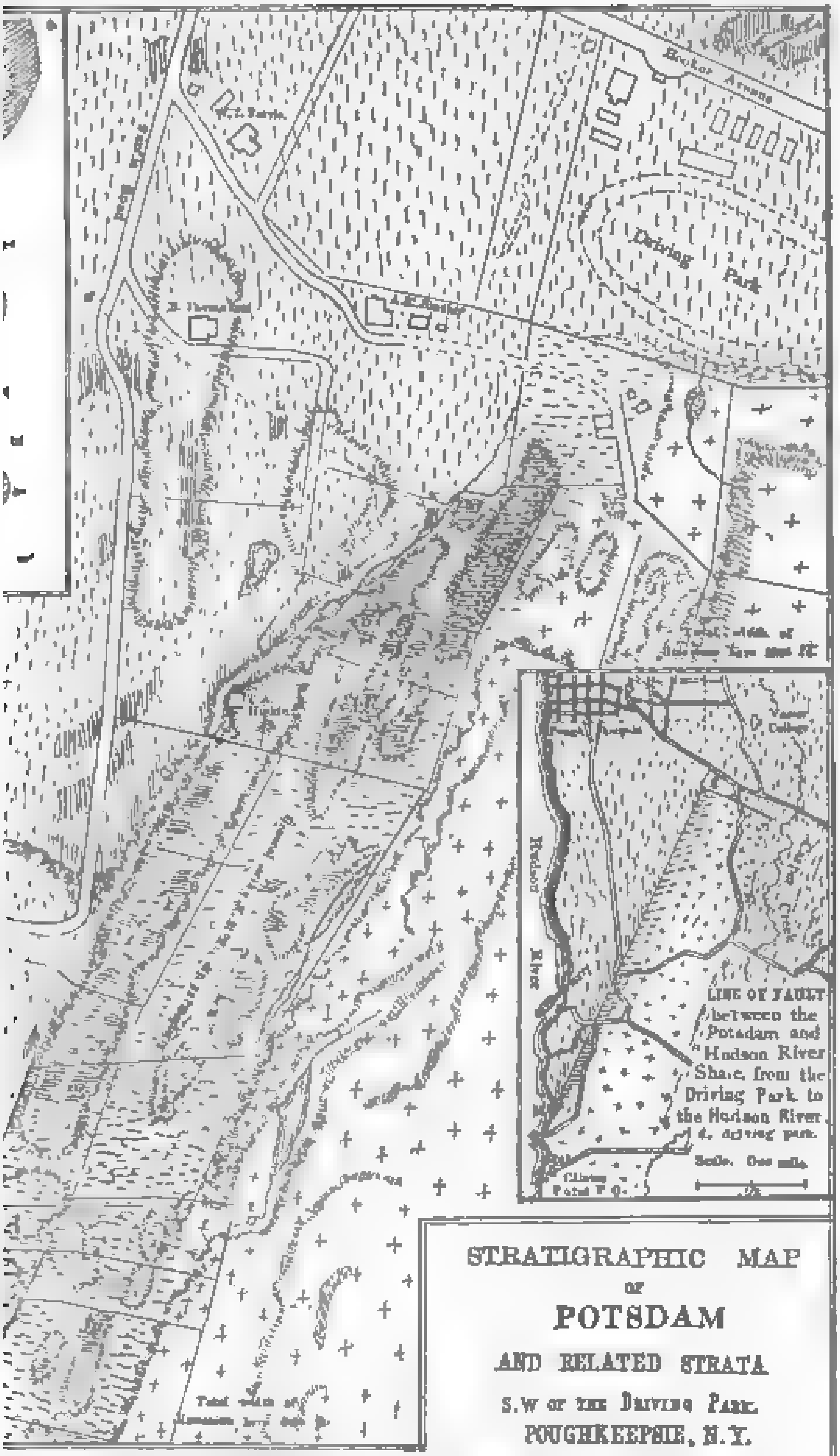
...tsdam mainly under drift. Potsdam, prominent outcrops.

...ssiliferous Potsdam. Hudson River Group largely under drift.

...dson River Group, prominent outcrops. Scale 1250 ft. to the inch.



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THE

[A]MERICAN JOURNAL OF SCIENCE.

[THIRD SERIES.]

[Art]. XVI.—*Examination of Dr. Croll's Hypotheses of Geological Climates*; by Dr. A. Woeikof, of St. Petersburg.

[T]he hypotheses of Dr. Croll have attracted so general atten[tion] in the last ten years, not only in Great Britain, but also in [the] United States and other countries, that a review of them [by a] meteorologist is, I think, desirable. This work is very [time]ly now, because Dr. Croll has just published a new book on [the] subject* in which he further explains and extends his views [and] answers his critics; and besides he mentions in the preface [the] fact that he wishes to devote the following years to work [in a] wholly different direction. Thus we have now before us a [syst]em as complete as it is likely to be made by the author.

[It i]s not my aim to review the whole work of Dr. Croll on [Climat]ial Geology and Cosmology, but only to consider some [poin]ts of it which are within my line of study.

[I]n his answer to Prof. Newcomb, Dr. Croll discusses the [mea]n temperature of land and ocean,† and arrives at the start[ling] conclusion that "the ocean must stand at a higher *mean* [tem]perature than the land." Now, since the *mean* and not *sur*[*face*] temperature is mentioned, the meaning of the author is, it [seem]s, clear, but the result is entirely opposed to what we know [to] be true. Not only have the oceans, which receive cold [cur]rents from polar seas, a much lower mean temperature‡ than

* Climate and Cosmology. Edinburgh, 1885. † Page 26 and following.
‡ I understand the mean temperature as that of the whole column of water [from] top to bottom.

the land, but even seas which receive no such cold water, and are known as being very warm, such as the Mediterranean and Red seas, have a mean temperature considerably lower than the land.

It might, perhaps, be remarked, that Dr. Croll's startling statement is a simple "*lapsus pennæ*," and that he does not consider the mean temperature of the whole column of ocean water, but *the mean annual temperature of the surface;* yet it is clear, especially from the statement on page 33, that such is not the fact. Dr. Croll considers the difficulty in the sea of "getting quit of its heat as rapidly as the land," and in this passage, as in the former, he seems to have forgotten entirely the mobility of the particles of water, which is so extremely important a fact and which so essentially affects the thermal relations of water by the convection currents which it causes. A few pages earlier he mentions the mobility of the particles, but only as causing the removal of heat from the tropics by ocean currents. Dr. Croll seems to think that the high temperature of the surface of the ocean is caused by the difficulty in the water to get rid of its heat by radiation, as if, here as in the case of land, loss of heat by radiation caused a low temperature of the surface. Now this is evidently not so, and the convection currents arising as soon as the surface temperature sinks below that of the stratum immediately under it bring the latter to the surface and thus maintain constantly a higher temperature of the surface than that of the other strata, but are rather conducive to a loss of heat by the whole mass, as the colder water sinks to the bottom where it is out of the reach of the radiant heat of the sun, and receives heat only by the slow process of conduction.*

Dr. Croll does not see that instead of "the difficulty in the water's getting rid of its heat" he really considers the cause of the high temperature of the surface of the ocean, and here misses the most efficient cause.

The next point I have to notice is this: "The quantity of heat lost by expansion must therefore be trifling in comparison of that lost by radiation; and, although the heat lost by expansion is fully restored by compression, yet the air would reach the earth nearly entirely deprived of the heat with which it left the equator. All that it could possibly give back would be the heat of compression, and that would hardly be sufficient to raise the air at 50° F. to the freezing point."†

As before, Dr. Croll mentions the temperature of the upper atmosphere, even under the equator as being 80° *F. below freez-*

* I consider here the case of a body of water having constantly a higher temperature than that of the maximum density. The oceans are certainly in that state.

† Pages 25 and 26.

ıg point, and as this is reached, according to him, at such a eight that the air, returning toward the surface of the sea, 'ould be warmed to the freezing point, it is clear that, in his pinion, the atmosphere is in a state of *unstable equilibrium, be-ıuse otherwise the temperature at which the upper strata arrive to ıa level would not be lower than the existing temperature of the ›wer strata*, but, in Dr. Croll's opinion, it is by 48° F. lower, as ıe mean temperature of the equator is about 80° F. and the ir of the higher regions, in sinking to sea level, would bring rith it a temperature of 32° F.

Now if really the case was such, if there existed an unstable ›quilibrium, why do not convection currents of great magni-ude arise in our atmosphere and bring a temperature of 32° to he sea level at the equator?

The reason why such convection currents do not arise is, that *the normal state of the air is that of stable equilibrium*, even a very stable one, so that, if by any cause the higher strata be forced down, they would acquire by compression a much higher temperature than the lower have.

An unstable equilibrium, a few cases excepted,* does exist in the lower strata, but only to a few thousand feet, and this only during daytime, when the surface of the ground is much heated by the sun. It disappears about sunset, even somewhat earlier. It does not happen in winter in high and even in higher middle latitudes (say from 50° onward). All this has been established by so numerous observations in mountain countries and on balloons that it can scarcely be doubted. In any case, if Dr. Croll is in doubt concerning such well known facts, that is, if he doubts that between the lower strata of air and those some tens of thousands feet high there exists a stable equilibrium, the *onus probandi* rests with him. In fact, a temperature −50° F. must be found at such a considerable height above sea level that the air, if forced down, would arrive warmer and not colder than the air existing at sea level.

Besides, I maintain that the radiation of particles of air is but a very trifling cause of loss of heat by our globe, and that by far the principal causes of it are the radiation of the surface of the ground (or snow) and that of the surface of the water. If the lowering of temperature of the surface of land and of the air be considered, the loss of heat by radiation of the surface of the ground (and snow) is by far the most important. I can much better agree with Dr. Croll in what he remarks about the conservative character of snow once formed, though, as will be seen further on, I do not agree as to the importance of winter in aphelion during high eccentricity.

Further, I think Dr. Croll does not well understand the

* For example, in thunder-storms, hail-storms, etc.

cause of the fogs, which have been so often noticed in high latitudes in summer. He thinks the fogs are caused directly by the melting of the snow, and that, by interposing a screen between the sun and the snow, they are effectual in lessening the amount melted.

The melting of the snow by the sun has not by itself power to cause fogs. On extensive continental regions of Europe, Asia and America, snow lies in winter and is melted from March to June, yet fogs are of exceedingly rare occurrence during that time, and they are more frequent at night. They are rather instrumental in preventing the loss of heat by radiation than the heating influence of the sun's rays. In the same regions fogs are frequent in autumn, during anti-cyclones. The cause of these fogs is the same as that of the London fogs, that is, the temperature of the river or lake water is much higher than that of the air, and thus the vapor is soon condensed. Neither are fogs common in summer over mountain glaciers, notwithstanding the great amount of melting, but fogs are experienced on the sea, in the vicinity of melting ice, because here we have two masses of air of unequal temperature, both nearly saturated, and their mixture must produce saturation, that is—fogs. Thus it is easy to see that fogs are not necessary followers of the melting of snow and ice *per se;* some other conditions are necessary for them, and Dr. Croll is right in saying about a glaciated country, at some distance from the sea, "fogs prevent, to a great degree, the melting of the snow and ice."

Mr. A. R. Wallace* has mentioned that in northern Siberia the powerful sun of June cannot melt the snow until warm southerly winds bring in warm air. In so far as the beginning of melting depends on this, I am quite of the same opinion; but Dr. Croll is wrong in extending too much the influence of these southerly winds, and in believing them to prevail in summer on the north coast of Siberia. On the contrary, cold winds from the sea prevail in summer and certainly chill the air, while southerly winds prevail in winter. Thus Dr. Croll's statement of "matters would be still worse if these southerly winds, instead of ceasing, were simply to change from June and July to December and January, for then, instead of producing a melting effect, they would greatly add to the snow-fall"† is realized, as far as the winds are concerned; but the snow-fall of winter is exceedingly light, because the southerly winds come from the colder interior of the continent, and besides they are descending winds, and in descending become relatively dry. We know these facts from the observations of Wrangell and Anjou at Nijnekolymsk and Ustjansk, and they were con-

* Island Life. † P. 83.

·med by the late observations of the Russian polar station of ıgastyr, at the mouth of the Lena.*

Dr. Croll returns over and over to the importance of knowing e temperature of space, as well in 'Climate and Time' as in s new book, and in the latter he is rather in favor of a lower ılue for it than that of Herschel and Pouillet, which he adop-d in 'Climate and Time.' He thinks this knowledge "of the most importance for the determination of the temperatures hich obtained during high eccentricity and winter in aphe-›ns, and repeatedly he admits that the temperature of a place, her things being equal, is proportional to the heat received ›m the sun. To make us quite sure of his meaning, he has a ble in 'Climate and Time,' p. 320, where he gives the value of centricity for different periods, and the midwinter tempera-re of Great Britain for periods of great excentricity and win-r in aphelion. So for example it was, according to him: −6·03° 850,000 years ago, when the excentricity was 0·0747; 1·03 F.° 0,000 years ago, excentricity 0·0575, etc. The temperatures Great Britain are evidently given only as an illustration, and ere is no doubt that a similar decrease of temperature was perienced, according to him, even in the midst of the Atlan-Ocean. Admitting even the present mean winter tempera-ıres there to be 6° F. higher than in Great Britain at the same titude, we would then have, at the highest excentricity with inter in aphelion −6·03° F. and 4·07° F. 210,000 years ago; ıat is, temperatures which were possible only if the ocean were overed with solid ice, which is an impossibility with anything ike the present geographical conditions; and Dr. Croll repeat-dly admits that they have not changed since the glacial epoch.

It is strange that Dr. Croll has not tried how his method vorks when applied to the existing mean temperatures of dif-erent latitudes. The mean temperatures from 10° S. to 10° N. ıave been calculated by different scientists; I use the calcula-ion of Ferrel as the most recent. The mean temperature of lanuary can be considered as the result of the position of the arth toward the sun at the winter solstice. Thus if we com-›are the mean January temperature of 50° and 60° N. we have

50° N. 21·3. 60° N. 1·7.

The quantity of solar heat received at the winter solstice on he 60° N. is but 0·35 of that on the 50° N. Thus, if the tem-›erature of the former was less in proportion to the quantity of olar heat received it should be −147° F. It is easy to see ıow large the discrepancy is.

Dr. Croll ascribes the relatively small decrease of tempera-ure with latitude to the influence of ocean currents, which ab-

* Izviestia of the I. Russ. Geogr. Soc., 1885, N. S.

stract warm water from the tropics and bring it to high latitudes. But on the 60° N. there is considerably more land than on the 50° N., and air over the land under 60° N. is colder than over the sea.

But to be quite sure to get beyond the influence of ocean currents, I will take the mean January temperature in the strictly continental climate of Eastern Siberia, under 120° E. According to Ferrel's tables:

Under 50° N. we have 0° F.
" 60° N. we have −30° F.

If the January temperature decreased from 50° to 60° N. according to the hypothesis of Dr. Croll, it should be on the 60° N., −155° F.

But to be quite sure of taking the most favorable case for the hypothesis of Dr. Croll, I take the highest January temperature on the 50° N. in Ferrel's tables, that is, that on 20° E. =44° F., and the coldest January temperature on the 60° N., that is, that of 120° and 130 E.= −30° F. Yet, in proportion to the quantity of heat received, the mean temperature of January on 60° N. should be −140° F.

The following table gives the results of the three cases considered:

	Mean temperature 50° N.	Mean temperature 60° N.		Difference.
		On the hypothesis of Dr. Croll.	Actual.	
Mean January temperature of all meridians	21·3	−147·9	1·7	149·6
Mean January temperature in 120° E. (East Siberia	0°	−155·3	−30	125·3
Mean January temperature of warmest meridian 50° N., and coldest meridian on 60° N.	44	−140	−30	110·

If the discrepancies are so great in taking even the means of a whole parallel, or strictly continental climates, and even in the last example, how much must Dr. Croll's calculations for Great Britain be wrong? In so oceanic a climate an equal difference in the amount of sun-heat will certainly cause a smaller fall of temperature.

I give another example which shows how little the method of Dr. Croll is applicable even to the mean annual temperatures. In chapter IX of 'Climate and Cosmology,' he states that the difference of temperature between the equator and the north pole ought to be at least 200° F., if they were in proportion of the heat received from the sun and the temperature of space

(—239° F.) was taken as the initial; but actually the difference is but 80° F. This small difference, as he thinks, is caused by the ocean-currents, which carry an immense quantity of heat from low to high latitudes. That ocean-currents have a great influence on the temperature of our earth I do not deny, but it is not so great as Dr. Croll believes.

To prove this I will take two places in as different latitudes as possible, and both not influenced by the ocean-currents. The first is Iquitos, on the Amazon, 3½° S. and about 300 feet above sea-level. The mean yearly temperature is 76·4° F. The reduction to sea-level would make it about 77·8° F., and the reduction to the temperature of the equator would give 78·3. Now Iquitos is more than 1,000 miles from the Atlantic, and, although nearer to the Pacific, yet separated from it by the chain of the Andes. It is to be admitted, then, that the place gives us a good idea of the temperature near the equator, uninfluenced by the heat-abstracting influences of ocean-currents. The other place which I choose for comparison is Verkhojansk, in N. E. Siberia, under 67° N., and having the coldest winter known on our globe, (January, —56° F.) It will, I think, be readily admitted that this place is out of the influence of ocean-currents, bringing heat from low latitudes, and in most favorable circumstances for radiation of heat. The mean yearly temperature of this place is 1·9° F., the reduction to sea-level may bring it to about 2·5.*

Thus we have, outside of the influence of ocean-currents, the following mean yearly temperature at sea-level:

Equator	78·3
67° L. N.	2·5
Difference,	75·8

Reasoning on the premises of Dr. Croll, we ought to expect a difference of 172° F. between the equator and 67° N. The actual difference is less than half that amount, scarcely over two-fifths; yet heat is certainly not abstracted from the vicinity of the equator, in the interior of South America, by ocean currents, nor are the continental regions of N. E. Siberia warmed by ocean-currents.

The Rev. O. Fisher† has already proved that if Dr. Croll's reasoning were right, the mean temperature of the equator should be by 21° F. higher in January than in July, on account of the greater proximity of the earth to the sun in the former month, while it is known that at most places on the equator

* The actual height is not known, but is in any case small.

† 'Nature,' vol. xxi, page 129; reprinted in 'Climate and Cosmology,' ch. iv, omitting some passages relating to the Rev. Fisher.

even the warmest and coldest months (which are generally not January and July) do not differ even by 3°, and nowhere as much as by 5°.

Dr. Croll has answered the Rev. O. Fisher,* and this answer is a curious example of the difficulties in which he has involved himself. The question as to why the annual range on the equator is so small is a very simple one. The quantity of heat received from the sun does not vary more than in the ratio of 100 : 115 and, besides, the observations on which depends our knowledge of the temperature of the equator, were mostly made on the sea-coast, two good reasons indeed for a small annual range. On the 50° N. the quantity received on the days of the winter and summer solstices vary in the ratio of 100 : 562, and yet in some places of England the yearly range is not above 20° F., and nowhere above 27° F. Thus it is the small annual range in many regions of the middle and high latitudes which much more needs explanation. Dr. Croll, in his reply, expresses the opinion that the Northern hemisphere is the dominant one, and, as the whole earth has a higher temperature in July than in January, so by the operation of this cause, the normal excess of the temperature of the equator in January is weakened and even abolished. I replied to this, that the temperature on the equator was nearly entirely influenced by cold winds, from cold ocean-currents, in some regions (the West coasts of Africa and America and the adjoining parts of the Pacific and Atlantic), and in these the equator was considerably colder in July than in January. For example, at the island of St. Thomas, West Africa, by 2·7. The cold winds come from the South, while winds from the North seldom reach the equator, and can never have a depressing influence on the temperature. In most places the temperatures on the equator were influenced by the rainy season, so that when it was at its height in January, this month was cooler than July, (this is the case even in Batavia, 7° S.), while when January was dry and July rainy, the former month was warmer, not only on the equator, but even to some degrees north of it. So for example, it is warmer by 7·2 at Lado, Upper Nile 5° N., and by 3·4 at Freetown, Sierra Leone, 8½° N.†

All this is, I think, conclusive enough, and proves that *Dr. Croll's system of estimating temperatures breaks down when tested seriously*. Small errors would be quite natural in a question of that kind, but I have shown that *the errors are enormous*, amounting to 100° F., and more; that is, *they are greater than the difference of annual temperature between the equator and the North pole.*

* 'Nature,' vol. xx, p. 577.

† 'Nature,' vol. xxi. p. 249; reprinted also in this Journal, 1880.

here is certainly a mistake somewhere; or, rather the whole hod is a failure. How can we judge of the change of tem-ıture resulting from this or that distance from the sun, even e knew accurately the temperature of space,* when we do know the diathermancy of the atmosphere under different litions? We know only that it is exceedingly different, ırding to the different quantities of carbonic acid and aque-vapor contained in it, and in a far higher degree, according ıe absence or presence in different quantities of suspended id and solid particles (clouds, dust, smoke, etc.) Thus, n we do not know in how far the loss of heat is impeded, ı an accurate knowledge of the temperature of space would f small use in this matter. I will illustrate this by a homely nple. Take a room where the fire is extinguished and the ·th or stove cold in the evening, and try to guess at the perature the room will have in the morning. If we fol-ed the method of Dr. Croll, we should inquire only about outside temperature, and not about the thickness of the s, the windows, etc. I think that, taking the average con-ction of Russian, English and Italian houses, if the inside perature was in all three cases 60° in the evening, and the ide temperature −20 in Russia, 32° in England and 45° in y, the morning temperature in the room would not be very erent, and probably even higher in the Russian room, owing ts thick walls, double windows, etc. It is also interesting ıote, that a calculation, by the method of Dr. Croll, of the ın January temperature of 60° N., as stated above, gives er figures than the extreme minima anywhere observed by ıble thermometers; this latter is about −81·4 F. (−63° C.) ther in the coldest parts of northeastern Siberia, nor in the hest latitudes of Greenland and Grinnell Land, have lower peratures been noted, and yet in Flacberg Beach the sun is ent from the horizon more than four months. The lower we ce the temperature of space, the more conspicuous is the ıcity with which the surface of the earth and the lower stra-ı of air retain a relatively high temperature.

Dr. Croll says in 'Climate and Time,' p. 43: "The stoppage ıll currents would raise the temperature of the equator 55°, t is, give it a mean temperature of 135°." Now such a perature is not only above anything known on the globe as mean temperature even of a single month, but the absolute cimum known by exact observations does not exceed 131° 55° C.) Though Dr. Croll repeatedly and quite rightly ıts out the far greater influence of ocean currents over air rents in modifying the temperature of the globe, he, quite

* I just see that Prof. Langley claims to have determined the temperature of e, but the actual figures and all details are still wanting.

unexpectedly, expresses an opinion as to the power of air-currents in cooling the temperature of the ground and air at the equator, which ought not to remain unchallenged. "No knowledge whatever as to the intensity of the sun's heat can be obtained from observations on the temperature of the air at the equator. The comparatively cold air flowing in from temperate regions has not time to be fully heated by the sun's rays before it rises in an ascending current and returns to the temperate regions from whence it came. More than this, these trades prevent us from being able to determine with accuracy the intensity of the sun's heat from the temperature of the ground; for the surface of the ground in equatorial regions is kept at a much lower temperature by the air blowing over it than is due to the intensity of the sun's heat."* Certainly no physicist or meteorologist ever thought of a determination of the sun's heat by observations on the temperature of the air or the ground, on the equator or elsewhere. But Dr. Croll evidently thinks that this would be possible on the equator, were it not for the influence of cool winds from temperate regions!

Let us first consider how far facts corroborate this opinion. According to Ferrel's tables, the mean annual temperature of 10° N. is 81° F.; of the equator 80° F.; thus the equator cannot be cooled by winds from the northern hemisphere, as the lowest latitudes of the latter are warmer than the equator. The cool winds must come from the south. Yet the mean annual temperature of 10° S. is 78·7, that is, only 1·4 lower than the equator. Even in July, the winter of the Southern hemisphere, the difference amounts to but 3·8, that is, in the annual mean to 0·14° F. for a degree of latitude, in July to 0·38° for the same. The greater part of the equatorial regions consists of ocean and islands, where, at least south of the equator, the *trade-winds* are prevailing. *They are not strong winds*, a few ocean regions excepted, they have a direction from the eastward and, blowing over very large extents of sea, *they bring to the equatorial regions the temperature which prevails over the tropical seas.* There can be no question of an influence of aerial currents from the middle latitudes on the temperature of the equator and the latitudes 10° N. to 5° S. at least. Two examples show how the thermal influence of stronger winds than the trades nearly disappears as soon as they have blown over an extent of about 1000 miles of sea. The coldest region of the tropics in winter is Southern China. Near Canton frosts are not rare in winter, the northeast monsoon blows as a strong, steady wind towards the coast of Cochin China, and yet at Saigon, but 12½° south of the tropic, the mean temperature of January is not below the normal of the parallel.

* Climate and Cosmology, Ch. IV, and 'Nature,' vol. xxi, p. 129.

'e have—

Mean temperature of January.

Canton, 23° N.	54·8
Hongkong (Victoria) 22° N.	59·5
Saigon, 11° N.	77·5

ıus, between Hongkong and Saigon, the difference per de- of latitude is 1·8° F. while the mean difference in Janu- ɔetween 10° and 20° N. is 0·77° F. per degree of latitude. ȝ we see, that when a cold wind from the middle latitudes ıes the borders of the tropical zone, it is soon warmed on ng over the broad expanse of the seas, and already north)° N. the cooling influence is not felt. The exceedingly l difference of temperature on the zone between 10° N.– S. is a proof that the cooling influence of winds from lle latitudes is not felt there. Another cold wind reaches ;ropical zone—the famous *Norther* of the Gulf of Mexico. is not a steady wind like the northeast monsoon of China; a cold wind blowing at times with the utmost violence. ;he mouth of the Rio Grande (26° N.) frosts happen every er, and even temperatures of 23° have been observed dur- Northers. The latter are frequent and dangerous at Vera ; (19° N.) but the temperature does not sink below 59°-51° nd below the exposed, relatively very cold plateau of fa, on the isthmus of Tehuantepec. Owing to their ex- e violence, the Northers keep for a longer distance a much r temperature than other winds of the tropical zone. Not- standing the Northers, the mean January temperature of ı Cruz (71·7) is not below the mean for the latitude. On ·xtensive wooded plain of the upper Amazons, weak winds calms prevail a great part of the year; and the S. E. ls of the drier months have so little power of cooling the ;hat at Iquitos the absolute minimum during a year was F. It is clear that in continental regions also, cold winds ı the middle latitudes do not reach the equatorial zone. It be fairly asked, where and how did Dr. Croll get his opin- about the cooling influence of winds from middle latitudes ;he temperature of the equatorial regions? Would it not ; been better to inquire about some of the best known ; of climatology, before speculating "à perte de vue" and ıtly stating that the mean temperature of the equator ld be 55° above what it is now, if it was not for the heat- racting action of ocean-currents. In fact, on the Upper azons there is no such heat-abstraction, and aërial currents ainly cannot have a cooling influence of even a degree F., yet the mean temperature reduced to sea-level is not any- ıg like 135° F., but below 80°. Besides the immense influ-

ence of the diathermancy of the atmosphere and its enormous variations in time and place, another exceedingly important consideration has been overlooked by Dr. Croll, viz: the very great difference of continent and ocean in the matter of temperatures, the fact that an equal loss of heat expressed in calories will have a very different influence on temperatures, both on account of the great caloric capacity of water and of the mobility of its particles. I must add that the latter condition is too often lost sight of not only by Dr. Croll, but by many other scientists in their speculations on the influence of a solid or liquid substratum on the distribution of terrestrial temperatures. Besides we have the formation of ice on the waters, which also has a great influence on the temperatures.

Thus it is easy to see, that the question how great will be the temperature of the air at a given place, say in midwinter, when the distance from the sun is greater or less than at present, cannot be answered, even approximatively, especially in the exceedingly crude way it is put by Dr. Croll, that is, without distinguishing high and low latitudes, continent and ocean, etc. One thing is certain, that such a change will certainly have a greater influence on the temperatures in the interior of continents than on the oceans and their borders. The caloric capacity of water is so great, and the mobility of its particles so effectual in resisting a lowering of the surface temperature, by the convection currents it causes, that I doubt very much if, during a great excentricity and winter in aphelion, the surface temperature of the oceans can be lower in winter than now: the difference in the quantity of sun-heat is too small and too short-continued to give an appreciable difference in winter; and, as in the year there is no difference in the quantity of heat received by the waters, I think there will be no difference in the temperature of the waters, and thus no influence of great excentricity with winter in aphelion on the ocean temperatures, and also no greater snow-fall than now. As to the continents, I admit that, though we are *unable to calculate the rate of decrease of temperature of the winter months* in these conditions, there is no doubt that *it will be appreciable, and be the greater the less a given place is under the influence of the seas.*

But what has this to do with glaciation? Even now, the temperatures in the interior of large continents are low enough in mid-winter to allow of the snow remaining on the ground for some weeks, not only under 45° N., but even under 40° N. And yet, we have no glaciers on the North American continent, which reaches to 71° N. and on the Asiatic, which reaches to 78° N., except in high mountain regions, because the snow-fall of winter is so small that it is melted in summer. Even the mountains of Northeast Siberia have no glaciers.

The greater part of the snow which lies on the ground in ›rtheast Siberia falls in autumn, when the air contains vapor water enough to allow of a great precipitation; the snow-l of winter contributes very little. Now what would a ·ther lowering of the temperature of winter produce? A ·ther diminution of the quantity of the falling snow. It ›uld thus even be melted sooner in the warmer, summer ›nths. The cold of winter in the interior of large continents, high latitudes, especially that of Asia, has a very important lirect result: the high pressure and the resulting cold and , winds of winter, especially toward the south and east of : region of high pressure. These winds, the cold, dry win-monsoon winds of Eastern Asia are unfavorable to snow-l; so that in the interior of Transbaïkalia with a mean nter temperature of −18° F. and below, there is generally › little snow for sleighing, and if the quantity of snow falling ar the mouth of the Amoor is larger, it falls almost entirely October and November, that is, at the beginning of the cold ason, and in the few days with east winds, which bring warmer d moister air from the seas, not yet frozen in these months. lower winter temperature and an earlier beginning of the ld in the interior of Asia would increase the pressure toward e north and the interior of the continent, and thus give a ·eater impetus, strength and duration to the dry northwest inds, which is thus less favorable to snowfall and an accumu-ıtion of snow.

In summer the winds in Eastern Asia are southeast, and arry clouds and rain far inland. Owing to the high tempera-ure of the continent and of the surrounding seas, rain and not now, falls on great heights, such as that of 15,000 feet in the ountains of Kansu in Western China (37° N.) Thus the ıeavy rains of summer are not favorable to an accumulation of now, but on the contrary assist in melting the small quantity which may remain on the ground.

During a high excentricity and winter in aphelion the tem-erature must be higher in summer and this would cause a ower pressure on the plateaus in the interior of Asia. This would increase the difference of pressure between the ocean and the interior of the continent and give a greater impetus to he moist winds and bring larger quantities of rain at least where the air is ascending. Such conditions would then favor he melting of snow at a greater height than now. At present, n Northern Thibet, for example, permanent snow is found at 17,000 feet; then it would disappear perhaps even from a ıeight of 20,000 feet.

The climatic conditions of Asia show us, so to say, the nor-mal reactions between continent and ocean. Everywhere there

is a tendency toward a higher pressure in the interior of continents in winter and on the oceans in summer, and to winds from the first in winter, from the second in summer, that is, there are what Coffin calls *monsoon influences.* A colder winter in the interior of the continents, with an unchanged temperature on the oceans, would certainly strengthen the winter winds from the interior, and thus bring more cold, dry weather than is experienced now, and reduce the precipitation in winter. Such conditions are certainly not favorable to a greater accumulation of snow than the now prevailing. The Ural mountains have, as well as those of Norway, prevailing west winds, and a much colder winter, but on account of the smaller snowfall, no permanent snow and no glaciers, while the west side of the Scandinavian mountains has enormous glaciers. If a high excentricity and winter in aphelion can have a considerable influence on climates, it would give to Western Europe colder winters with a greater proportion of dry east winds and warmer summers, both conditions unfavorable to glaciation. It has long seemed to me that those who have expressed an opinion on the favorable influence of winter in aphelion on glaciation, from Adhémar to Dr. Croll and his followers, have been influenced by the present difference of the northern and southern hemispheres. The glaciation is far more prevailing in the latter, and this has been ascribed to winter in aphelion on the well-known principle "post hoc, ergo propter hoc," as it gave a ready explanation of the former glacial periods of the northern hemisphere. I am quite sure that Dr. Croll was also influenced by the present differences of both hemispheres.

Dr. Croll has long been an advocate of the wind theory of ocean currents and has proved that, at present, a considerable quantity of warm waters is brought by these currents from the southern to the northern hemisphere, serving to warm the latter. In these two questions he has rendered a good service to science. The transport of warm waters from the southern to the northern hemisphere is a fact, but what is the cause? Dr. Croll believes the cause to be, at least indirectly, winter in aphelion, which brings, especially during high excentricity, but to a certain degree even now, a host of other indirect results, by which the given hemisphere is cooled, its trade-winds are strengthened, and bring the more warm water into the other hemisphere, the higher the excentricity. I have shown above that the cause assigned by Dr. Croll is inadequate to cause any considerable lowering of temperature on the ocean in winter, and that even the small difference, perhaps possible, must be regained in summer. Thus winter in aphelion can not bring any change in the velocity of the trade-winds and their more southerly extension when winter in aphelion exists in the

ırthern hemisphere, and the reverse during winter in aphelion the southern hemisphere. Why then are the trades of the uthern hemisphere blowing in the northern at present and so why are the conditions more favorable to glaciation in the uthern than the northern hemisphere? There are certainly ›od reasons for that.

1. The extent and depth of the oceans of the southern hemihere. This gives a greater steadiness and force to the winds that hemisphere, and the difference is even more marked if ɜ compare the westerly winds of middle latitudes rather than e trades, though also well seen in the latter. Now land acts two ways on the trade-winds; it weakens them, first, by the crease of friction. But this is not all. The trades, few ocean gions excepted, are not strong winds, they are important on count of their extent and steadiness. The gradient which uses them is small. Now in such cases land, even if it is not continent but only a cluster of small islands, has a great influıce on trade-winds in causing local gradients which may have ⁄en an opposite direction to the general gradients, thus causing ifferent and even opposing winds. The land- and sea-breezes nd the monsoons are cases in point. Even where the disturbnces of the normal ocean gradients are not large enough to ause monsoons, we see generally the trades oftener interrupted n summer, when they are weaker and when local thunderstorms and rains are more frequent on land. For the two reasons given, the trades of the southern hemisphere must be more extensive and stronger than those of the northern.

2. The relatively small extent of sea in middle latitudes of the northern hemisphere, in comparison to the southern, must tend to warm the seas of the former, even if the quantity of warm water from the tropical seas reaching them be equal. Thus, generally in the middle latitudes, the evaporation goes on at a higher temperature from the seas of the northern, than the southern hemisphere. Now, this has a very great influence on the resulting precipitation; when the evaporation goes on at or near 32° there is much more probability that the resulting precipitation will be snow and not rain even on low lands; the higher the temperature at which the evaporation takes place, the greater must be the height at which snow can fall, on account of cooling by expansion.

3. Not all cold seas are favorable to glaciation. If they are surrounded by land on which the winters have a temperature considerably below 32°, they will be covered with ice, and thus evaporation will be checked just at the time when it is most favorable to snowfall. The ice of the seas will be covered with snow, the temperature of the air over it may be very low, but the snowfall will not be great and thus the conditions not favor-

able to glaciation. Such is the condition of many seas of the northern hemisphere, as the Arctic ocean north of Siberia, the Kara sea, the bays and inlets north of the North American continent, the sea of Okhotsk, etc., which are covered with ice during many months. These conditions are favorable to cold of many months duration, but not to a large snowfall and the resulting glaciation. The observations made at many points off the coasts of Siberia and the North American archipelago have shown that the snowfall is exceedingly light. The seas between 45°–70° of southern latitude are deep and not surrounded by land, and thus by far not so ice-bound, both on account of the absence of very low temperatures favorable to the formation of ice, and of the rupture of the ice, when formed, by winds and currents. Such seas as these are very favorable to snowfall and glaciation on land, since, even in mid-winter, there is a great extent of water which evaporates freely. The only parts of the northern hemisphere where glaciation is considerable, outside of high mountains, is the region from Greenland to Francis Joseph Land, but here we have rather cold seas, which are yet not entirely ice-bound even in winter. These seas are more favorable to snowfall and glaciation than those around Great Britain, because colder, and than those of the North American archipelago, the Kara sea and the Arctic ocean near Siberia, because less ice-bound in the cold season.

4. The intense glaciation of the highest southern latitudes gives an enormous quantity of icebergs floating northward, that is to the seas of lower latitudes. As the surface of the southern seas to about 62° S. is below 32° F., even in mid-summer, the icebergs cannot melt till they reach that latitude, and their immense size enables them to reach sometimes even the 35° S. They certainly cool the waters, and thus produce conditions favorable to glaciation even in lower middle latitudes. This, besides, is a further direct cause of lower temperatures, and an indirect cause of stronger and more extensive trade-winds, which reach to beyond the equator and bring much warm water to the northern hemisphere. The geographical position is also favorable to this, especially the situation of Cape St. Roque and its vicinity.

It is easy to see from all this, that there is no necessity to seek for the reason of the difference of the northern and southern hemispheres as to glaciation, by calling to aid the winter in perihelion of the former and the winter in aphelion of the latter; much simpler causes explain the result. The operation of these causes is exceedingly well illustrated in the glaciation of a part of the higher latitudes of the northern latitudes, while to the east and west there is none, with lower mean annual temperatures.

nother example from the southern hemisphere. Its ographical conditions are favorable to glaciation, but everywhere equally. Thus the higher latitudes of part of South America have as little snow, even in the warmest parts of the European continent under atitudes, while a degree or two to the south South deeply glaciated. As to South America, I must dis- with Mr. A. R. Wallace* as to the condition of ent being a proof of the influence of winter in aphe- ciation. Besides what is stated above as to the con- the eastern part of the continent, I may mention the snow and glaciers from the highlands of the Atacama ve 10,000 feet high) and those between the coast and aca (above 14,000 feet). Only in the western part tinent, and south of 35° S. is glaciation prevailing. , in the northern hemisphere, have we so enormous of sea westward, with such regular and brisk west nging an immense quantity of vapor, which is con- o snow? The amount of precipitation on the west he western slope of the mountains of South America, 40° S., is scarcely equaled anywhere in the tropics. , geographical causes explain the result. The same id of the west coast of the southern island of New Here also high mountains rise, and to the west is an stretch of ocean, uninterrupted to the east coast of erica. The snowfall is enormous and glaciers reach above sea-level under 43° S. and yet the mean tem- t sea-level is higher than in other meridians of the emisphere and the greater part of the northern also. two examples given above, evaporation takes place of relatively high surface temperature, about 50° F. nd in such cases permanent snow can begin, only at of some thousand feet, because air rising to such a ooled by expansion and its vapor precipitated in the ow. Mr. A. R. Wallace† has very well shown the of high land for glaciation, though, to my mind, he oo far in not admitting the possibility of glaciation on

conclude. An English geologist of note‡ has Croll's hypotheses brilliant and fascinating. So nly are. The originality of the conception, the fer- source of the author, his indomitable will, are sym- the highest degree. It is with a melancholy feeling fess that interesting and important as are some parts em of Dr. Croll, the main points of it are opposed to certain teachings of meteorology and can not be

fe, page 142 ff. † Island Life. ‡ Mr. Searles Wood, Jr.

accepted. Besides the purely geological and cosmological part of his work, which I do not consider here, and the tables of excentricity, what can be accepted? The wind theory of the upper oceanic currents, the notion of the great climatological effects of these currents (though by far not in the exaggerated extent given to them by Dr. Croll), some of his considerations on the conservative effects of snow and ice. *The main points on which rests, so to say, the whole fabric in its explanation of glaciation and geological climates generally—the influence of winter in aphelion and perihelion during high excentricity and the calculation of temperatures in proportion to the sun-heat received—are, unfortunately, fallacies.*

Geologists will have to look for other causes to explain the more or less frequent glacial and interglacial periods which their studies lead them to admit.

ART. XVII.—*Tendril Movements in Cucurbita maxima and C. Pepo;* by D. P. PENHALLOW.

(Continued from page 114.)

Conclusion.

With these facts before us, we may now proceed to discuss the various phenomena and draw such conclusions from them as appear justified.

Temperature.—The observations here recorded appear to be in harmony with the views generally received, that within certain limits, and with the conditions otherwise favorable, higher temperatures are promotive of the most rapid growth. According to the experiments of Sachs* upon the germinating seeds of *Cucurbita*, the most rapid growth was found to take place under the influence of a temperature of 33·7° C.; but we have to observe that the growing embryo was doubtless placed under conditions which permitted the normal tension of the parts upon which observations were made to be fully preserved. In our own observations, the greatest growth, or greatest tendril movement, was made under a temperature of 24·4° C., while the most rapid growth of the vine occurred when the temperature ranged from 29° to 36·6° C. It is important, however, not to lose sight of the fact that in these cases, we have to deal with modifying influences which affect growth through the tension of the tissues, a disturbance of which frequently occurs as a result of high temperature. Thus, if we compare an even number of hours of growth when the temperature is above 30° C., with the same number when

* Text-Book, p. 647, etc.

the thermal range is from 25° to 30° C., we shall find the growth in the latter case to be greater as the following show, where six observations covering the same hours of day are compared.

No. of obs.	Aver. temp.	Total growth.	Aver. growth per hour.	Rel. hum.
6	27·0° C	2·0 in.	0·333 in.	high.
6	34·9	1·6 "	0·266 "	low.

These figures show that there is a well defined limit to the temperature which is most beneficial to plant growth; and, furthermore, that this limit is not fixed, but is variable according to the attendant conditions. Certain exceptions to the general law seem at times to appear, as when the most rapid growth coincides with the maximum temperature, but these instances are really conformable, and are capable of explanation upon the ground that (1) the maximum temperature was in reality not very high, and (2) that if high, the conditions of humidity were at the same time most favorable, or (3) that these very rapid growths were only extreme fluctuations in a very variable wave, and this will appear from a careful inspection of the figures given. The same will be found to hold true with reference to all the observations here recorded.

The relative humidity of the atmosphere, or the degree of saturation as dependent upon temperature, exerts a direct influence upon the condition of tension in growing tissues, and consequently upon the growth itself, by inducing more or less rapid transpiration of moisture from the leaves. While, therefore, increasing temperature directly promotes growth on the one hand, it indirectly retards it on the other. Again, taking the figures already given, and comparing the atmospheric humidity with the results there shown, it will be seen that the greatest growth was obtained under conditions of greater moisture, therefore when transpiration was reduced to the minimum. On the other hand, the least growth was made under conditions of less humidity, and therefore when transpiration was active. Doubtless, also, the humidity of the soil exerted an important influence upon the processes of growth as observed, but, unfortunately, no record of this was kept, and the relations which it bore to growth cannot now be brought out as they should be.

Alternations of day and night cause a marked influence upon, and variation in, the phenomena of growth. Light generally exerts a retarding influence,* and other conditions being equal, we should naturally expect to find the greatest elonga-

* Sachs, Text Book, p. 755. Arbeiten das Bot. Inst. in Wurzburg, 1871. Bot. Zeit., 1865.

tion of the axis, greatest increase in the weight of the sq and most rapid movement of the motile parts, during the l between sunset and sunrise.

From the experiments now under consideration, we find the growth during hours of darkness was in reality less that during daylight, since we obtained in the case of ten a movement of $1359{\cdot}90^{cm}$ for the day, against $536\ 90^{cm}$ fo night; and in the growth of the vine, $44{\cdot}44^{cm}$ for the against $34{\cdot}28^{cm}$ for the night. Rauwenhoff found tha growth in *Cucurbita pepo* for twelve hours of day, was 56·9 cent of the whole, thus leaving only 43 per cent for the number of hours of night, or a ratio of 1 : 1·32 in favor o former. Our own results are in striking confirmation of since as already seen, our ratio is as 1 : 1·29 in favor of dayl In the case of the tendrils, the superior influence of condi during the day, becomes much more manifest.

The movements of the tendrils are found to occur in defined waves of greater and less activity, which, usually lo and of slower movement at the outset, are of decreasing le and greater activity with advancing age up to a certain pe This, however, is soon reached, and beyond this point movements become somewhat longer, but more espec slower, with greater maturity.

It is also important to note that the motion of the tendı always most rapid when accomplishing its grand sw through the central region of the figure it describes, but th becomes slower and more intermittent when it reaches its treme lateral position on either side. This is often very r fest in the figure obtained, but may be seen more clearly the waves of growth are plotted. This fact was noted by win* as occurring in the *Cucurbitaceæ*, especially in *Echinoc* but he does not appear to have gained a solution of its c Nevertheless, there is every reason to believe that it origi directly in the unequal torsion of the tendril arm, which w of course be greatest at the extreme lateral range, and pro the most variable action, while it would be least and give to the most uniform and regular movement, when th reaches the central region of its course.

So long as all the tissues remain soft and in an actively g ing condition, the waves of growth will succeed one anoth accordance with the controlling influences already spoken of as there is an advance in age with general hardening of the ti and large formation of wood, a noticeable and general le ening of the waves ensues. The tip may even drop to the ground as if exhausted and not resume its nutations for or even two hours. When it does, it is generally with a r sluggish action.

* Climbing Plants, p. 129–30.

From our previous considerations, it is clear that the movement of the tendril is but a normal manifestation of growth, which is subject to the same influences as other vital phenomena. It now concerns us to determine how this motion is produced. This we shall discuss under the following headings:—

(1) Growth in length.
(2) Torsion.
(3) Effect of irritation.
(4) Circumnutation.
(5) Spasmodic movement at the end of activity.
(6) Coiling about a support.
(7) Free coiling.

Growth in length.—We have already seen that the tendril arm begins to revolve as soon as it has unrolled from the bud and becomes straight. At this time it is in a state of rapid elongation through its entire length, and while the full length ultimately reached must necessarily be largely determined by the time at which it comes in contact with an object of support, the arms generally attain a length which is nearly or quite twice that which they have when first unrolled from the bud. It is therefore obvious that most rapid extension is simultaneous with the greatest activity, and the two are directly correlated throughout the entire period of movement. It is therefore, to this very rapid elongation that we must look in the first instance, for a true explanation of the movement, while secondarily, we must consider the differentiation of the component tissues, particularly in their relations of mutual tension.

The structure of the tendril, presenting as it does a diversity of tissues, at once shows that this rapid elongation cannot be partaken of by all the tissues in equal degrees. The fibro-vascular bundles and the zone of wood cells are those elements in which the least extension can occur, of all the tissues present. With reference to all the other tissues, therefore, these elements must be brought into a state of positive tension, which increases in strenth as age advances and the component cells become more strongly modified by the formation of secondary layers, thus making them more resisting.

The collenchyma tissue is also a structure which, while it may be capable of greater extension than the elements previously considered, is capable of comparatively little elongation after it is once fully formed. It may exert a positive tension on the wood cells and thus bring themselves into a state of negative tension, but with reference to all tissues in a more active state of growth, it is constantly in a condition of very strong, positive tension. This may be at once seen on making sections. Transverse sections are found to quickly bulge out in the center,

with a strong, marginal contraction, which is found to be developed in the collenchyma itself. Longitudinal sections show a strong curvature with the concavity on the side along which the collenchyma runs, clearly demonstrating the strong tension of this tissue. We are also inclined to believe that the cutting, as all other irritation, causes a certain loss of water from the tissue within the area of irritation, and thus through condensation, a contraction and further increase of tension. This is essentially the view adopted by Sachs,* and it certainly appears justified. We must therefore not only regard the collenchyma as influencing all the movements dependent upon growth, but it must also be considered as that tissue which chiefly determines all movements caused by mechanical irritation, a view which is amply supported by its presence in the tendrils of *Vitis*, *Sicyos*, *Ampelopsis* and other vines, and the relation which it there bears to the movements of these tendrils.

The unmodified fundamental tissue, of large, rounded cells filled with protoplasm, is that in which the most rapid and continued increase takes place. As the central or pith region early loses its vigor and often shrinks away radially, that part lying externally to the wood zone and internally to the collenchyma is obviously the general region of this tissue which serves to retain the power of growth for the longest period, and of this, we find the vibrogen bands to not only represent the most active growth from the outset, but they retain it up to the latest period. Even after the tendril has become well fixed in a permanent spiral, the vibrogen will be found to contain an abundance of chlorophyll and protoplasm, and thus to essentially retain its power of extension, although then held in abeyance by the permanant character of the fibrous tissues. We must then conclude that the negative tension is most strongly developed in the parenchyma as a whole, and in the vibrogen in particular, while the positive tension is developed in all the fibrous elements, particularly in the collenchyma during the earlier periods of activity, and in the wood cells towards the close of the active period.

The collenchyma also bears an important relation to the other tissues in its hygroscopic powers. It is a tissue which is capable of the greatest variation of density through absorption and liberation of water, and whenever such a change is induced by any means, this tissue must become of primary importance in determining secondary movements in the tendril to which it belongs. From the information we have collected, not only with reference to this but to other tendrils as well, we feel tolerably safe in the view, that, in all cases of sensitive tendrils, the

* Text Book, p. 869.

collenchyma tissue is that in which the modification of tension is first determined.

Torsion.—We have seen in a previous paragraph, that when the tendril arm becomes straight from the bud and begins its circumnutations, the tip is turned slightly downward, or toward the rounded side of the arm. Soon after movement has commenced, it will be observed that the plane which the tip makes with the basal portion of the arm, does not maintain the same relative position, but that it continually changes. Thus the tip may point up, or down, or even sideways. If we follow any one of the collenchyma or vibrogen bands, throughout its entire length, we shall also find it to assume a variably spiral form, conforming to the direction of the tip. There is thus produced in the tendril, incident to its most rapid elongation, a distinct torsion which frequently turns the tip through 180°, and sometimes through 270°. Moreover, it will be found that the petiole of the tendrils develop a similar and strong torsion, as is clearly defined by the longitudinal bands.

The explanation of this torsion is simple when we remember the character of the tissues composing the tendril, and the very great difference of tension which is developed between them; while from our previous considerations, it must be clear that, in both tendril arms and petiole, the torsion is but the natural result of excessive growth in the vibrogen, exerting a strong positive tension upon the collenchyma and wood tissues.

Irritation.—Of the two sides of the tendril arm, that which is uppermost and slightly channeled is the least sensitive, while the power to respond to mechanical influences appears to be centered in the lower portion of the arm where the collenchyma is most abundant, and this leads us to infer that it is this tissue which is chiefly concerned in such changes. If the vibrogen were the chief factor in such cases, then the change of direction must follow one of three planes, to the right, the left, or upward, and also the effect of irritation would be most conspicuous when the vibrogen was touched. On the other hand, however, since the bending is almost always toward the lower side, at least never lateral, and since the collenchyma is particularly sensitive, we have strong proof pointing to the view that the bending is produced by a full maintenance of tension in the vibrogen, while that of the collenchyma on the side irritated is increased, and the growth of this tissue ceases for the time owing to contraction of the protoplasm from the cell walls, according to the well known influence of irritation upon living protoplasm.* The power of the tendril to respond to irritation, therefore, is correlated to the hygroscopic power

* Weiss, Allgemeine Botanik, pp. 81 and 82. Darwin, Insectivorous Plants, p. 38, &c. Häckel, Quart. Journal Mic. Sci., April, 1869.

of the tissues themselves, through which variable tension is most readily produced. We are thus led to the conclusion that the collenchyma is the most important tissue of the entire structure for the production of bending under the influence of mechanical stimuli.

A tendril subjected to local irritation for about thirty seconds develops an abrupt curvature at that point within one or two minutes, and not only continues to bend so long as the irritating body is present, but even for a few seconds after its removal. Puncture with a pin, or the action of a loop of thread, produces the same effect. Irritation over considerable length causes a longer curve for the same distance. There is in all such results no evidence that the impulse has been conveyed to portions lying on either side of the irritated parts, and very soon after the cause is removed the tendril straightens out and resumes its circumnutations as before. A blow, however, produces a different effect. When given on any part of the arm, the latter receives an impulse which extends through its entire length, and instead of developing one long curve or a single abrupt turn, it is thrown into a series of long waves. Also, irritation at the tip produces the effect of a long curve passing through the whole central region. These facts distinctly show that the terminal portion is much more sensitive than any other part of the tendril, and that irritation given there, or imparted to other portions by percussion, is directly transmitted through the entire length. That this transmission is accomplished through the protoplasm, which thus serves as the nerve material, can no longer be doubted in view of the continuity which we have shown to exist, coupled with the well known sensitive nature of this substance.

Circumnutation.—Our attention is first of all to be directed to the fact pointed out by Darwin* and confirmed by our own observations, that the "tendrils revolve by the curvature of their entire length, excepting the sensitive tip and the base, which parts do not move, or move but little." This clearly shows that whatever force is in operation, acts uniformly through the entire length of the whole motile organ, and that the movement does not have a local origin at or near the base. We must therefore conceive, as both Darwin† and Sachs‡ explain, that there is a longitudinal band of tissue, or rather that a line of cells extends from base to tip of the tendril, and that this band, or these cells are in a more active state of growth than those in other parts of the tendril, thus bending the latter toward the opposite side. So far, our observations are in strict harmony with these views; but they do not accord with the opinions of these eminent authorities when they state that

* Climbing Plants, p. 170. † Ibid. ‡ Text Book, p. 866.

these bands of growth "travel round the tendril and successively bow each part to the opposite side," and in this lies the essential part of the true explanation of the movement.

As already indicated, the figure described is not one of regular progression through successive points of an ellipse or other figure, but the tendril tip may change its direction very abruptly, often exactly retracing the path just passed over, or the change of direction may be less abrupt (fig. 2). This indicates in the first place, that the band of growth does not pass regularly through successive points in the circumference of the tendril, but that it changes its position without regard to order of succession. But it also appears from the figure obtained, that while revolving in this irregular manner, the total dextrorse and sinistrorse movements are practically equal.

An examination of the histological elements of the tendril as exhibited in cross section, together with the well defined relation of the different tissues with reference to tension, suggested that the true explanation of the movement was to be found in the vibrogenic tissue. But it appears (fig. 3) that these bands are three in number, two being lateral and one superior, the latter passing along the upper side of the tendril. If, therefore, they were the true source of the movement as described in fig. 2, then the lines traced must be developed as follows:

We must conceive that, while the parenchyma tissue grows most rapidly, and therefore exerts a determining influence in the circumnutation, the collenchyma and wood tissues of slower growth must also produce a secondary influence which will modify the direction determined by the vibrogen, and thus produce a resultant motion. Thus, line 1–2 (fig. 2) would result from excess of growth in b' or in collenchyma a, a' (fig. 3). But at 2, the direction of movement is reversed, and back to 3 it must be the resultant of excess of growth in b'', plus a weaker growth in collenchyma a''. From 3–4, vibrogen b' exerts a superior influence, while from 4–5, b has again the ascendancy over all the other tissue and the motion is therefore directly lateral. And so on for the other lines traversed, each change of direction being the direct expression of superior energy in one of the vibrogenic bundles, or the resultant of growth in both vibrogen and collenchyma, the excess of growth always being in *one* of the vibrogen bundles. But this result might be produced without the energy being specially localized at b, b', b''. The band of growth might pass through various points of the parenchyma tissue at c, c', c'', and thus cause the tendril to bow in various directions as explained by Sachs and Darwin. If, however, the vibrogen tissue exerts a preponderating influence, then, since two bands are lateral and one superior, the figure

described must show that the total latitudes (assuming the three bands to be of equal size and strength, which they are, approximately) are one-half the total departures of movement. The following table exhibits the latitudes and departures for the thirteen tendrils experimented upon.

TENDRIL MOVEMENTS.

Total Latitudes and Departures.

No.	Lat.	Dep.
1	124·30	249·70
2	53·25	116·60
3	123·35	269·40
4	21·00	60·83
5 c	43·37	91·10
5 b–c	241·80	398·55
6 a–b	141·75	266·55
7 a	87·75	192·80
7 b	47·75	69·30
8 a	106·30	264·70
8 b	67·65	203·03
8 c	53·20	144·50
9	122·40	118·15
Totals	1193·87	2445·21
Means	91·84	188·09
Ratio	1 :	2·05

From this it will be seen that the total mean fully confirms our theoretical considerations, giving in round numbers, latitudes 91 and departures 188, or a ratio of 1 : 2·05. An inspection of the figures for each tendril, shows that in many, this ratio is fully preserved; in others, the excess is in favor of the latitudes, but we have already shown that the lateral range is greatest in the most active tendrils, and that the motions became more irregular and in latitude, greater, as the tendril becomes older. Since it has already been explained, that the vibrogen tissue induces torsion of the tendril, it is clear that this latter is intimately associated with the circumnutation, since both have a common origin.

Spasmodic Movement.—It has already been noted that the movement of the tendril becomes somewhat spasmodic toward the close of its active period. Periods of rest, or of actual cessation of motion not only occur, but there is often greater irregularity of movement, and a failure to make those grand sweeps, often so conspicuous a feature of the rapid circumnutations. If we bear in mind the gradual modification of the tissues during the period of movement, and more particularly toward the end of activity, the proper explanation will be easily reached

le the vibrogen tissue constantly maintains its full tension, wood cells are becoming continually thicker, therefore ǝ permanent, less capable of extension and hence constantly ·loping a greater resistance to the general elongation of the n as a whole. So long as this mutual tension remains con- ·, i. e., so long as the tension of the woody structure is ısed by continued growth in proportion to the development ıe vibrogen, for just such time will the motions of the ten- be comparatively regular. With increasing positive on, however, its normal release will necessarily become ɜ intermittent on account of the modified character of the in which it occurs, and the resultant motion of the whole ril arm must show corresponding irregularity.

ɔiling about a Support.—The coiling about an object of sup- with which the tendril comes in contact, results from ɔmbination of causes already discussed. We have al- y seen that at the period of contact, the tip first of all ıes closely about the object, while the basal portion actu- passes by, through continuation of the movement, until ss of torsion draws it up into a double spiral. The coiling he tip is the direct result of irritation as already shown by ıs and Darwin, and as the latter explains,* it is developed . shortening of the side in contact with the object, the same ıge, i. e. condensation of structure through cessation of rth and loss of water, operating here as in the previous ;, and with Darwin, we can hardly agree with Sachs† the coiling is in any way promoted by *accelerated* growth in ınirritated side.

'hen once the growth in length is arrested, as it appears to ɔon after coiling, the maturity of the tissue is the predom- ng feature. Each tendril must be regarded as having a nor- period within which all the changes of structure are to be mplished. This may be, and undoubtedly is, shortened by ıanical influences which are sufficiently long continued, so the maturity of a young tendril is much more rapid after ng grasped a support than would otherwise have been the This has already been pointed out by Darwin. On the r hand, it is difficult to conceive that the normal period is l prolonged for the purpose of enabling the tendril to find pport. Unless a tendril comes in contact with an object re its tissues reach a certain stage of development, it can- grasp a support at all. This is well shown by the fact that ·endrils which are near the end of their activity, often catch but imperfectly, or if they secure a hold, fail to properly ·ct their double spiral.

·ee Coiling.—The changes incident to the free coiling of the

*Climbing Plants, p. 181. †Text Book, p. 859.

tendril have already been discussed incidentally, and it is only necessary to repeat in concise form, that coiling of this nature is simply due to increasing disproportion of tension in the various tissues, through maturity and cessation of growth in the wood cells.

It only remains for us to now call attention to the fact that the motions of leaves, petioles and tendrils are all due to one and the same cause, and that the much greater activity and range of movement manifested in the latter, finds ample explanation upon histological grounds: (1) in the much greater disproportion between length and diameter, (2) in the more strict localization of the vibrogen tissue, (3) in its greater flexibility through being comparatively solid, and (4) the greater effect of unequal tension when exerted longitudinally through a more filamentous structure.

In the nutation of the terminal bud of the squash vine, we have to deal with some conditions which do not generally obtain in vines, i. e. the horizontal position of the plant. The growing extremity for a distance of two or three feet from the tip, under the influence of negative geotropism, has a strong tendency to an upright position, which results in a gradual curve and the elevation of the terminal bud from twelve to eighteen inches above ground. As growth continues, the tip constantly ascends until that portion of the vine unsupported by the earth, has attained such length that it can no longer overcome the direct action of gravitation upon its mass. The bud is then seen to be rapidly depressed, but this downward movement is succeeded by an upward growth as before. These vertical oscillations continue as long as growth of the vine, and constitute the chief movements of the extremity.

A second class of movements is found in the irregularly ellipsoidal nutations of the bud. This may be directly referred to unequal growth on opposite sides of the stem. While in the bud, the internodes are very nearly in a straight line with one another. Later, however, when the development of leaf, flower and tendril proceeds at a much more rapid rate than the growth of the stem at the same node, the excessive formation of tissue on the side where these organs are inserted, causes a bending of the stem in the opposite direction. This must, therefore, throw the tip of the vine to one side of its former position. As this condition of unequal growth occurs at every node within the section of growth, the tendency is to throw the extremity first to one side and then to the other, and the final direction of movement is controlled by the excess of growth upon one side, over that on the opposite side. This conclusion was reached by me independently in the summer of 1875, and it was gratifying to notice somewhat later, that Sachs had been led to similar conclusions, though at a somewhat earlier date.

›m the facts here presented, we feel justified in the follow- ›nclusions:

Growth is promoted by an increase of temperature and dity.

Growth may be retarded by an increase of temperature other conditions are not favorable.

The conditions favorable to growth, arising from temper- and humidity, may cause greater growth during the day, position to the retarding influence of light.

Growth is retarded by excessive transpiration.

The conditions to which the plant is subjected being va- ;, there is a corresponding periodicity in the vital phe- na.

Movements of tendrils and terminal buds, being phenom- f growth, are modified by whatever variations of condition growth.

th reference to the circumnutations of the tendrils, the ving appear justified:

Movements of the tendril and petiole are due to unequal th by producing unequal tension of tissues.

The unequal growth is chiefly defined in the vibrogen ;, which may therefore be regarded as the seat of move- .

The band of unequal growth does not arise at successive s of the circumference.

The vibrogen tissue consists of three longitudinal bands, of which becomes more active in turn, without regular .

Bending under the influence of irritation results from ces- ı of growth and condensation of structure.

The collenchyma tissue is that which is chiefly concerned riations of tension under mechanical stimuli.

Coiling results (by contact) from cessation of growth and ensation of structure or (free coiling) from increased ine- ty of tension due to continued growth.

Transmission of impulses is effected through continuity of plasm in the active tissues.

XVIII.—*Note on a Method of Measuring the Surface Tension of Liquids*; by W. F. Magie.

ISSON, in his Nouvelle Théorie de l'Action Capillaire, p. gives a formula determining approximately the height of ge liquid drop standing on a level plate. It contains the lary constant a, which equals the square root of twice the

surface tension divided by the specific gravity, the height of the summit of the drop above the plate, the radius of the greatest section of the drop, and the contact angle between the drop and the plate. The formula holds, without any change, for a bubble of air formed in a liquid under a level plate.

If we transform this formula to get a value of a we obtain

$$a=\frac{k}{\sqrt{2}\cos\frac{\omega}{2}}+\frac{a^2}{\mu\sqrt{2}\cos\frac{\omega}{2}}-\frac{a^2}{3l'\sqrt{2}\cos^2\frac{\omega}{2}}\left(1-\sin^2\frac{\omega}{2}\right),$$

where k is the height of the bubble, ω the contact angle, and μ the radius of curvature of the summit of the bubble. The symbol l' is defined by the equation $l'=l+(\sqrt{2}-1)a$, where l is the radius of the greatest section of the bubble. If the bubble considered be large, that is, if it have a radius of 30 mm. or over, the value of μ, as determined by an equation given by Poisson on p. 216, is so great that the term containing it may be neglected, and the surface of the bubble at the centre treated as plane. If we measure the height of the bubble and know the contact angle of the liquid and the plate, we get a first approximation to the value of a by the use of the first term of the formula. By substitution of this value in the remaining term, we proceed to a second approximation, which in the case of large bubbles is usually sufficient.

When the liquid is of such a nature that it wets the plate under which the bubble is formed, it is usual to assume that the contact angle is zero. The formula then becomes simply

$$a=\frac{k}{\sqrt{2}}-\frac{a^2}{3\sqrt{2}\,l'}.$$

Doubts have, however, been thrown on the validity of this assumption by the work of Wilhelmy,* Quincke,† Traube‡ and others, and it cannot yet be considered as justified by experiment. It can only be verified by a careful comparison of the results obtained for the value of the constant a by the use of different methods of measurement. It was for use in such a comparison that the method described in this note was contrived.

In place of the telescope of an ordinary cathetometer was placed an arm carrying at one end a vertical microscope. In the center of the object glass of the microscope was fastened a small piece of white paper. It was brightly illuminated by the rays from an incandescent electric lamp, which were concentrated by a lens, and reflected upon the paper from a small mirror. The bubble to be measured was formed under a glass

* Pogg. Ann., cxix, 177. † Pogg. Ann., cxxxix, 1.
‡ Journ. für prakt. Chem., new series, xxxi, 514.

e supported by three porcelain rests in a glass dish. The stood upon a low table furnished with levelling screws. liquid to be investigated filled the dish above the lower ace of the plate, but did not cover the upper surface. With arrangement it was possible to obtain bubbles over 10^{cm} iameter of almost perfectly circular section, and by careful ipulation of the levelling screws to bring the bubbles nentarily to rest under the middle of the plate.

/hen the bubble was formed and had become as nearly sta-ary as possible, the microscope was brought over its center, lowered until it was sharply focussed on the image of the ɜr reflected from the approximately plane surface of the ble. The position was then read on the cathetometer scale, the microscope raised by means of the tangent screw of cathetometer, until it was focussed on the image of the ɜr reflected from the lower surface of the glass plate. The tion was again read on the cathetometer scale. It can easily hown that the difference of these two position-readings was ıl to the height of the bubble. The scale of the cathetom-could be read directly by means of a vernier to twentieths millimeter.

he diameter of the bubble, which only enters in the correc-term, was measured with sufficient exactness with an ordi-r millimeter scale.

he results which I have obtained by the use of this method pare very favorably for uniformity with those given by any ır method. They are presented in the following tables, in ɜr to show what may be expected of the method. They are however, to be taken as final results.

he values for k and l are given in millimeters, and a^2 is ɜu instead of a, as it is the constant usually employed.

Distilled Water.

k	l	a^2	Temp.
5·60	56	15·093	22° C.
5·56	56	14·962	22
5·59	63·5	15·179	19
5·57	63·5	15·070	19
5·57	57	15·031	19
	Mean,	15·067	
5·65	53	15·398	6
5·605	55	15·179	6
5·634	52·5	15·311	6
5·64	55	15·367	7
	Mean,	15·314	

Absolute Alcohol, sp. gr. 0·7934 at 15·6° C.

k	l	a^2	Temp.
3·437	45·5	5 760	16·6° C.
3·45	47·5	5·808	14·4
3·442	50	5·789	
3·407	60	5·698	12·8
	Mean,	5·764	

Olive Oil, sp. gr. 0·914 at 18° C.

k	l	a^2	Temp.
3·917	55	7·491	18·6° C.
3·872	52·5	7·317	19
3·914	47·5	7.447	18
3·892	52·5	7·387	18
	Mean,	7·410	

Petroleum, sp. gr. 0·808 at 16° C.

k	l	a^2	Temp.
3·682	60·5	6·641	15·4° C.
3·753	57·5	6·891	15·4
3·717	52·5	6·744	15.2
3·717	52	6·744	16·5
	Mean,	6·755	

Each of the above values of k is the mean of several (usually four) independent measurements. The figure in the third decimal place is the result of the division by which the mean was obtained. The original readings were made by estimation to hundredths of a millimeter.

In order to compare the above results with those given by other observers, it is necessary to reduce them to a common temperature. For this purpose I have used the coefficients given by Brunner or Frankenheim and Sondhaus. The final mean for a^2 obtained for water at 0° is 15·54. Laplace uses 15·36, which is the value usually adopted by the older observers. In a recent series of measurements by a method not involving the contact angle,* I obtained 15·00 as a value for a^2. Mr. Durell, Fellow in Experimental Science at Princeton, who has kindly undertaken for me a series of measurements of a^2 from the rise of liquids in capillary tubes, has obtained the value 15·62. The discrepancies in these different results, while they show that much remains to be done in perfecting the various experimental methods, still show nothing as to the validity of the assumption that the contact angle is zero; for, if this assumption be untrue, the value of a^2 obtained by methods not

* Wied. Ann., xxv, 421.

volving the contact angle should be greater than that obtained om the height of bubbles, and that again greater than that otained from the rise in capillary tubes. No inequality of this rt is apparent.

The value of a^2 for alcohol, reduced to 0°, is 5·941. That otained by Quincke from the rise in capillary tubes is 5·906, id that obtained by me from the method above mentioned, hich does not involve the contact angle, is 5·843.

For olive oil the reduced value of a^2 is 7·602. Brunner ves 7·461, Quincke 7·366 from the rise in tubes, and I ob-ined, from the method mentioned above, 7·315.

For petroleum the value of a^2 at 0° is 7·034. Mr. Durell btained, from the rise in tubes, the value 7·204. The variable haracter of petroleum renders a comparison with the results iven by other observers useless.

The same remarks may be made on the comparison of results or alcohol, olive oil and petroleum that have been already iade in the case of water. The discrepancies in the results re not such as to lead to the conclusion that the assumption f a zero contact angle is false, in the case of any of the four quids used. The difficulties offered by some of the methods nployed, and unavoidable differences in the materials used by ifferent observers, renders any positive statement at present npossible. It is my hope soon to be able to present a con-ected series of observations, which will perhaps lead to some ore definite conclusion.

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.RT. XIX.—*Wm. B. Rogers's Geology of the Virginias. A Review*; by J. L. and H. D. CAMPBELL.

(Continued from vol. xxx, p. 374.)

IN our further treatment of the subject before us, we shall mit our remarks to the most salient points in the higher ormations of the geological system of the Virginias, basing iem chiefly upon personal observations, and making them applementary to the comprehensive and able discussions ound in the volume under review.

Niagara Group, IV, V, R. (5*a*, *b*, *c* and 6).—In Virginia this omprehensive group consists of alternating beds of conglom-rates, hard sandstones and shales—calcareous shales predomi-iating in the upper portion, in which occasional beds of mpure limestone occur. In the State Reports the whole eries is described under two divisions, IV and V of Professor

Rogers's series; but in his final chapter, p. 717, he puts the whole of IV and the greater part of V together as constituting the Niagara group (5*a*, *b*, *c*), while he regards the higher calcareous shales and limestones as representing the Salina period (6). It is gratifying to find him so ready to subordinate his own system of notation and nomenclature to the more generally applicable and altogether superior system now rendered classic in the science through its adoption by the leading American geologists.

The bold escarpments of Medina and Clinton beds constitute a conspiuous feature in the Little North Mountain and its several outlying ridges, along the western margin of the Great Valley, as may be seen in the Jump and House Mountains of Rockbridge, and in Purgatory and other ridges in Botetourt county. While the dip of these sandstones and the overlying shales is generally toward the northwest, or normal, as far northward as the Jump Mountain in Rockbridge county, an abrupt change occurs at this point, and throughout the remainder of the range, nearly as far northward as the Potomac, the eastern margins of the beds are either inverted or thrown into a vertical position. This inversion is conspicuous where the C. & O. Railway passes through Buffalo Gap, ten miles west of Staunton.

A number of ridges, essentially parallel with the North Mountain range, lie between it and the outcropping margins of the coal rocks farther west, occupying a belt of mountainous country from 20 to 40 miles in width and more than 300 miles in length. The framework of these ridges is generally the massive sandstone beds of 5*a*, *b*, while they are flanked most commonly by remnants of 6, and of several higher groups, as 7 and 8. They are remarkable for their numerous anticlinal arches and folds which usually constitute the crests of the ridges; and for the comparatively wide and shallow synclinal troughs that intervene, and carry the remnants of higher and less durable formations, among which the dark shales of 10 are conspicuous.

The Clinton beds of this group carry, in many places, valuable beds of the fossil and red-shale iron ores, which have been extensively mined in Pennsylvania, Virginia, Tennessee and Alabama, and are noted for the superior quality of iron they yield.

Salina Group.—The existence of the Salina in the Appalachians of Virginia may be regarded as yet an open question. If it has any representative here it is to be found in the calcareous shales with occasional beds of limestone, mentioned by Professor Rogers under V. But while there is reason to suspect that a portion at least of the higher beds of that series

belongs to the Salina (6), additional explorations are required to settle the question definitely.

Lower Helderberg, VI, R. (7), *and Oriskany*, VII, R. (8).—In the recent revision of Professor Dana's "Table of Geological Formations, 1885," we find that he makes the Helderberg the topmost period of the Silurian age, and makes the Oriskany the base of the Devonian. Whatever may be the chronological relations of these two formations, we find them in Virginia to be entirely conformable, to be coextensive with the Appalachian range, to blend considerably into each other in some places—the limestones of the former becoming very siliceous in its upper beds, while the sandstones of the latter are sometimes, though less frequently, calcareous where they come in contact with the underlying limestone beds. While the organic remains of the Helderberg bear close relations to those of the preceding Salina and Niagara periods, they seem to be just as nearly related to those found in the Oriskany, though much more abundant. In Virginia the relations of the Oriskany fossils to any remains found in the Devonian seem to be rather remote. Therefore we are still inclined to hold that "the Oriskany sandstone strata are the passage-beds between the Silurian and Devonian," but truly Silurian. This formation is characterized in Virginia by extensive beds of limonite ores.

We are here treating these groups in conjunction because in our mountain ranges they are most intimately associated. The one rarely, if ever, appears without the other; and where their beds have not been ruptured by contortions and foldings—that is, where the undulations have been such as to give the strata moderate dips—the durable sandstone of the Oriskany is left undecayed in many localities to form the crowning beds of mountain ridges of considerable height, and thus protects against erosion the less durable beds of Helderberg limestone beneath.* As a rule, however, where the sandstones of the Niagara period have been thrust up to a considerable height, the Helderberg and Oriskany strata have been so much ruptured that their fragments have been removed from the higher parts of the ridges by denuding agencies, and their outcropping edges alone are now to be found low down on the slopes and spurs. The Helderberg limestones being more easily disintegrated than the Oriskany sandstones, are often hidden from view, but their position is still indicated by a depression between the sandstone and the main ridge, forming a well-defined "bench" on each spur, while in the adjacent ravines,

*We have a striking and very interesting illustration of this arched structure at the celebrated Blowing Cave in Bath county, three miles west of Millboro Station on the C. & O. Railroad. By a singular oversight Professor Rogers locates the cave in the Oriskany instead of the Helderberg. See this Journal, vol. xviii, pp. 121 and 125 (1879).

eroded by mountain streams, the beds of limestone are commonly denuded, and the two formations may be seen in close contact. The very intimate relations thus shown between these two formations, and the abrupt transition to the next higher group incline us, as already stated, to regard them both as belonging to the same general geological age.

The Corniferous Group of Devonian age (9*a*, *b*, *c*), as far as our observations have extended, and as far as we can draw any inference on that point from Rogers's Reports, has no well-defined representative in the Virginia portion of the Appalachians, we therefore pass to the next higher series, on which we wish to make a few remarks.

No. VIII, R. (equivalent to 10*a*, *b*, *c*, and 11*a*, *b*, Dana), consists of a remarkable series of slates that are found crowded into folds and crumpled masses in the synclines between the sandstone ridges of 5*a*, *b*. The "Black," the "Olive" and the lower portion of the "Ochreous" divisions of Rogers appear to coincide with the *Marcellus*, *Hamilton* and *Genesee* (10*a*, *b*, *c*) of the New York series; while the higher portions of the ochreous beds doubtless represent the equivalents of the Portage and Chemung groups (11*a*, *b*). In many of the valleys where 10*a*, *b* slates form very conspicuous features of the topography in the form of slaty ridges and knobs of various size and shape, beds of 11*a*, *b*, if they ever constituted a prominent feature, have been almost entirely removed by denuding agencies. The remaining slates of 10*a*, *b*, *c* have been so much crushed and warped by the compressing forces exerted by elevation of the bordering sandstone ridges, that it is difficult to determine their thickness with certainty. But in the middle portion of the range, at points where they have been least disturbed and least worn down by erosion, as for example, in parts of Bath and Alleghany counties, we have found them to have an average thickness of about 750 feet. In the higher parts we find some beds of limestone containing remains of corals, crinoids and mollusks of Devonian type.

Catskill group, IX, R. (12).—This series of strata evidently constitutes a transition period from Devonian to Carboniferous age. Its lithological features as represented in its numerous and heavy beds of brown micaceous sandstones, its conglomerates and ochreous shales, and what remnants it contains of vegetable and animal life, although distinctly Devonian, all suggest at least an approaching resemblance to what we find in the overlying, and essentially conformable, beds of the Sub-carboniferous period.

Sub-carboniferous, X, XI, R. (13 *a*, *b*.)—The two divisions of the Sub-carboniferous group are quite well characterized in Virginia, especially in the middle and southwestern parts of the

eastern border of the great coal-field; but the lower division, 13 *a*, is especially worthy of notice, as it is here a real coal-bearing formation. At the date of Professor Rogers's Reports, (1835–41), it promised to be of great economical importance to the State, on account, first, of the intrinsic value of much of the coal found in it; secondly, of its proximity to extensive beds of iron ores, and to points in the general market; and thirdly, of the fact that the eastern portion of the State was, at that period, cut off in a great measure from the coal-field west of the Alleghany range, by want of lines of transportation. But since several railway lines have brought the products of the richer and more available mines into competition with those that are less productive, and more expensive to work, very little mining has been done except to meet demands for local consumption.

Although this limited field has ceased to have any great commercial value, it still possesses a scientific interest from its relations to the salt-wells on the Holston and the Kanawha rivers.

The history of geological investigations and speculations regarding the origin of the beds of gypsum and salt, found in the valley of the north fork of the Holston, in Washington county, is both interesting and instructive. The problem of the true geological relation of these minerals has for a long time been under discussion. Traversing the little river valley in which they are found is a remarkable line of faulting, by which the beds of Sub-carboniferous, 13 *a*, *b*, have dropped down on the northwest side, or the Canadian limestones of 3 *b*, *c*, have been thrust upward on the southeast side, to such an extent that the two formations are now on the same level, although at other points, where they still retain their normal relations to each other, they are several thousand feet apart.

Near this line of dislocation, beds of gypsum, in rather irregular concretionary masses, have been opened and mined at a number of points over an area of several square miles. Within this general area a number of salt-wells have been sunk, penetrating beds of rock-salt of considerable thickness. From the strong brine of these wells salt has been manufactured for many years.

As to the gypsum, all agree that it was once corbonate of lime, changed now to sulphate by the action of sulphuric acid from the adjacent pyritous shales, but there has been a difference of opinion as to the age of the limestones from which the gypsum was produced. In relation to the source and mode of accumulation of the salt beds, there has been a like diversity of opinion. Prof. Rogers himself seems to have greatly modified his views of this region at different periods in the history of his

explorations. In his State Report for 1837 he locates these gypsum and salt beds in the upper part of his No. V—probably Salina or No. 6 of Dana's series. In the Report of 1838 he appears to have found the source of the gypsum at least, in the limestones high up in his No. VIII. Then, in his notes prepared in 1878 for Macfarlane's Railway Guide, he says of the salt and gypsum, that "Both deposits are probably referable to the Sub-carboniferous period." If the solution of this problem proved so difficult and perplexing to a profound and accomplished geologist like Prof. Rogers, it becomes us to approach it with modesty. The question, however, seems to be still open for discussion and for differences of opinion.

In Prof. Dana's Manual of Geology, revised edition, 1880, p. 233, these deposits are referred to the Salina period, (6). Prof. Lesley in his Report on the Geology of some of the southwest counties of Virginia, 1871, regards the gypsum as produced by the action of sulphuric acid or sulphuretted hydrogen from the "Lower coal-measures," on the Lower Silurian limestones of the Holston valley. His theory of the accumulation of the salt is thus expressed: "The appearance of brine in such quantity and of such strength must be considered a local phenomenon explainable without reference to the gypsum. Such an explanation may be found in the very curious lake deposits of the little triangular plain at Saltville; a deposit evidently made in a deep little lake or pond basin filled with red mud, and saturated with salt-water, gypsum drainings, etc. . . . . The salt lies in a solid form, mixed and interstratified with compact red marl or clay, 200 feet below the water-level of the Holston; and the borings have gone down, at the salt-works, 176 feet further without reaching the bottom." If this be the true view, the salt lake must have been formed and filled at a period subsequent to the production of the fissure above mentioned; perhaps in Permian or in Mesozoic time. If the question as to the source of the salt of these beds is ever finally settled, that source will most probably be found in the Sub-carboniferous; in that case the question becomes analogous to that in regard to the same formation in Kanawha valley, where Rogers says, "from these strata there is every reason to believe are derived the saline ingredients which enrich the salt wells of that enterprising and prosperous region," (p. 373).

Saltville is easily accessible by rail, and is surrounded by a variety of interesting geological features, besides the beds of gypsum and salt.

Conglomerate Coal Groups, XII, R. (14 *a*).—The great conglomerate bed, called by English geologists, "Millstone Grit," seems to have been regarded by the early geologists of this country as one simple bed underlying the whole of the Appala-

chian coal-field. But in Virginia, Rogers determined forty years ago, that there were two distinct divisions of the Great Conglomerate, with intervening "seams of coal between these divisions." Hence the lower division is now recognized as the floor of only a sub-division of the true coal measures, to which Rogers gave the appropriate designation, "Conglomerate Coal Group." To him belongs the honor of having determined its true status in the Virginia series, and yet it has most probably proved to be far more important, (as developed in the Quinnemont mines, on New River, and the Blue Stone and the Pocahontas (Flat Top) mines farther to the southwest), than was anticipated by him, when, forty years ago he wrote about it, more as having a prospective than a determined value.

Above the Conglomerate group Rogers recognizes four subdivisions, to which, in his table, p. 717, he applies the terms "Lower Coal Group," "Lower Barren Group," "Upper Coal Group," "Upper Barren Group." The first three seem to be covered by Prof. Dana's 14 *b*, *c*; and the last appears to coincide with 15. For we find on his geological map the area of the "Upper Barren Group" represented as of Permian age,* and mapped down as bordering on the Ohio river, from the mouth of the Great Kanawha to the vicinity of Wheeling, and covering nearly the whole of two tiers of counties along that margin of the State.

MIDDLE SECONDARY, (16–17).—Such is Rogers's designation of the groups of *Mesozoic age.* The lower portion he regards as embracing the Triassic and Jurassic blending into each other; and hence applies to it the term, "Jurasso-Triassic," (16–17), while for like reason he calls the higher portion "Jurasso-Cretaceous," (17–18). Rocks of this age in Virginia are found altogether east of the Blue Ridge, and so far as yet determined they rest, not upon rocks of the next preceding age, but upon Archæan beds—usually in trough-like depressions, or perhaps in basins of erosion. The extensive areas covered by these rocks are generally of irregular oval form, and in interrupted belts having a general N.E. and S.W. trend, corresponding with the usual course of the outcrops of the Archæan beds. The Mesozoic coal field near Richmond forms an exceptional case—its longest axis being north and south, and hence parallel to the corresponding part of the Atlantic coast.

It is worthy of remark, that the northwest margin of the belt of Mesozoic rocks, north of James River, skirts the southeastern base of a range of ridges running nearly parallel with the Blue

* Prof. Fontaine, of the Virginia State University, and Prof. White, of the University of West Virginia, seem to have established the identity of a number of species of the flora of this group with those of the recognized Permian in other regions, American and foreign.

Ridge, and known by different names, as Cittocton Mountain in Loudoun county, Bull Run Mountain in Fauquier; and farther to the southwest, its several parts are known as South-west, Green and Findlay's Mountains. This leads to the inference that the broken range thus designated was the shore line of the Mesozoic sea in which these groups of strata were originally deposited.

Another point worthy of note, in connection with the topography of the tracts, is that they differ from one another but little in their elevation above tide-level, though separated by intervals of many miles. This has been determined by the surveys of the railway lines by which they are severally traversed, and on which we give the elevations of only such points as are actually on Mesozoic strata. For examples, on the Virginia Midland Road, Manassas station is 317 feet above tide; the average elevation from that point to Culpeper is 300 feet; the portion of the Manassas and Strasburg branch of the same road, as far as it runs on this formation, has an average elevation of 351 feet, the minimum being 317, and maximum 395 feet. On the Richmond and Danville road, Coal-field station is elevated 320 feet above tide, and Powhatan station 317 feet. Farmville on the Norfolk & Western road, where it crosses Mesozoic rocks, has an elevation of 316 feet. At these several points only the Jurasso-Triassic beds (16–17) are found, with none of the newer beds of Jurasso-Cretaceous overlying them, hence we may conclude that they were elevated above the level of the sea before the Cretaceous epoch. And, after making allowance for a considerable amount of erosion and denudation, we may very reasonably conclude that the sea bottom, which received the latest deposits of 16–17, has been lifted through a space of at least 400 feet above present tide-level, plus the depth of the water in which those deposits were made; and that the uplift was simultaneous and very uniform in extent, over an area 200 miles long and 50 or 60 miles wide, or fully one thousand square miles.

TERTIARY AGE.—*Eocene*, *Miocene*, *Pliocene*, (19 *a*, *b*, *c*.)—Rocks of this age cover a very large area in the eastern part of the State. A line from Aquia Creek, on the Potomac, running south through Richmond and Petersburg to the North Carolina line, would mark out approximately the western border of this area, while it covers all the territory between that line and the Atlantic coast. Its total length is about 130 miles by a meridional line, and its width from Richmond eastward to the mouth of the Rappahannock River is about 65 miles, and at the latitude of Norfolk 80 miles.

Although Quaternary Drift obscures much of the surface of this Tertiary region, the banks and bluffs of the many

streams traversing it afford numerous exposures of Tertiary strata, with their characteristic lithological features and fossil remains. These are readily accessible on several lines of railway, and along the rivers below Fredericksburg, Richmond and Petersburg.

We shall direct attention to only a few points of special interest in connection with Prof. Rogers's work in this interesting field. As early as 1835 he writes, "The existence of an extensive Eocene formation in eastern Virginia is now for the first time announced as furnishing an interesting step in the geological inquiries which are now on foot," etc.

The Miocene covers the greater part of the Tertiary of Virginia, but we shall note only two points of special geological interest, as illustrating the appreciation the scientific world has placed upon the work of Rogers in this portion of his great field. His description of the cliffs near Yorktown, and the detailed account he gives of the contents of their fossil beds, have made that region classic ground for the modern geologist, and have given the Miocene the title of "Yorktown Group"—a title found in almost every extended discussion of the Tertiary age among American writers.

A second point relates to the history of the first discovery of the famous *infusorial bed*, which crops out conspicuously along the slopes of the hills on which the city of Richmond stands, and at several other places in Virginia, as well as on the Maryland side of the Potomac. Although this interesting feature of our geology has for years commanded the attention and admiration of the scientific world, and the beautiful picture of its diatoms developed by Ehrenberg's microscope, become familiar to the eye of every geologist, we doubt whether many of our younger co-workers know much about the history of its first discovery. We deem it proper, therefore, to say that, after giving a general account of his first discovery and microscopic examination of the contents of this wonderful deposit of what was then regarded as "infusorial animals," Rogers says, "In view of these interesting facts, the discovery of the *infusory Stratum*, as one of the members of our series of Tertiary deposits, cannot fail to be regarded as an important addition to our knowledge of the Tertiary of this country, and has the greater interest at present, as being the first example yet observed in the *United States* of the occurrence of infusorial remains in any but the most recent geological formations." His latest view of the geological position of this formation is, that it is near the base but still within the Miocene group. We are ready, from personal observations, to accept this conclusion.

Virginia and West Virginia together present a vast field, embracing within itself an almost complete system of geological

formations, of which we have given only some of the prominent features. While a great work has been done by Rogers and others, the material of the field is far from being exhausted; and the amateur student can readily find access to any particular formation or group, which he may desire to make a special subject of study.

Washington and Lee University, Lexington, Virginia, 1885.

ART. XX. — *Observations on the Tertiary of Mississippi and Alabama, with descriptions of new species;* by D. W. LANGDON, JR., Geological Survey of Alabama.

In the following notes will be found a statement of some personal observations upon the Tertiary of Alabama and Mississippi, made the past season, which may help to settle the point of dispute recently raised over the stratigraphy of the region.

JUST above the Vicksburg and Meridian Railroad bridge over the Pearl River at Jackson, Miss., and on the west bank, the following section is exposed:

Pearl River Section, No. 1.

Surface soil and drift pebbles........................ 8 feet.
1. Calcareous blue joint clay, very much like the "Rotten limestone" of the Cretaceous. Fossils generally decomposed, *Pecten nuperus* Con., *Ostrea pandæformis* Gabb, well-preserved. Lower portion full of a madrepore known locally as "nigger heads"............ 15 feet.
2. Fossiliferous marl containing the "Jackson" shells, slightly glauconitic. Upper portion reddish, lower part bluish gray. Not very sandy................ 10 feet.

From a point a few hundred yards below the railroad bridge, following the river down, there are seen no exposures of Tertiary strata until arriving at a small bluff on the east side of the river and estimated to be about a half mile south of Jackson. Here an exposure of the calcareous clay (No. 1, of the above section) six inches thick, is seen just above the water. This streak continues for two miles, never showing more than two feet of strata until reaching Richmond Lake Bluff, four miles a little west of south of Jackson, where it shows four feet thick overlaid by river alluvium. The last of these clays disappear below the water about a half mile further down the river. The fossils of this clay are principally *Ostrea pandæformis* Gabb, *Venerecardia planicosta* Blain., and other shells too friable to be distinguished, as well as fragments of Crustacea. The outcrops up to this point are not extensive enough at any one place to estimate the amount of the dip, but the direction

s plainly southern, as the clays (No. 1 of my section 1) are ieen at the water's edge here. For several miles nothing is ieen along the river bank, but finally at a point ten miles)y river (about six directly) above Byram the "lignitiferous ands" mentioned by Hilgard* first appear as in Section 2.

Pearl River Section, No. 2.

. Laminated gray micaceous sands very slightly argillaceous, containing fragments of leaves, and bits of lignitic matter, but no fossils distinguishable	4 feet.
. Earthy lignite	3 feet.
. Gray micaceous sands to water level	6 in.

The strata show at this point a dip of about twenty feet in a iundred toward the south. The exact point of contact with he Jackson clays is not seen, but the gap between this section nd the last exposure of my No. 1 of section No. 1, is not nore than a quarter of a mile, and as both show a southern lip, the natural inference is that their distance apart vertically annot be great. About a quarter of a mile still farther down he river there is an evidence of slight rolls in the strata, but he tendency of the dip still remains southerly. A gap of bout a quarter of a mile then occurred and the gray sands vhen next seen were dipping southward very rapidly, as much is five feet in a hundred, and fully fifty feet of strata are exxposed. This dip, as well as the one previously noticed, is ibnormally great, and is probably due to some local disturbince. In the upper part of the fifty feet observed, the sands became somewhat indurated, forming overhanging ledges two or three feet thick, the lower portions contained bits of lignitic naterial and pyrite; a large log two feet in diameter and comletely lignitized, was also seen. Another gap of about a quarter of a mile occurred and then appeared the first evilences of Vicksburg strata in a high bluff on the east bank of the river, where the following section is seen:

Pearl River Section, No. 3.

Surface soil, growth mainly *Pinus australis*	4 feet.
. White limestone, upper portion decomposed, lower part harder and slightly crystalline; contains *Orbitoides Mantelli*† Mort., *Pecten Poulsoni* Mort., and casts of several bivalves	4 feet
2. Gray calcareous clay containing *Pecten Poulsoni* Mort., and other fossils all very friable	4 feet.
3. White limestone containing some indurated irregular ledges,—no fossils seen	5 feet.

* This Journal, p. 268, No. 178, vol. xxx.

† Under this name I include the two species usually ascribed to this genus.

4. Highly fossiliferous decomposed greensand, the grains of quartz small,—fossils mainly casts and showing a preponderance of bivalves—*Pecten Poulsoni* Mort., *Orbitoides Mantelli* Mort., very well preserved—*Conus sauridens* Con., *Cardium Vicksburgense* Con., and *Buccinum Mississippiensis* Con., as casts........ 4 feet.
5. White limestone with *Orbitoides Mantelli* Mort. Showing to water's edge about 200 yards farther down stream where it is about 12 feet thick .... 8 feet.

Talus obscuring face at this point.................... 6 feet.

The appearance of the limestone at this point resembles more closely that at St. Stephens in Alabama than any I have yet seen in Mississippi. A half mile below we have

Section 4.

1. White limestone containing a few greensand grains and occasionally an *O. Mantelli* Mort............... 4 feet.
2. Decomposed greensand indurated and breaking off in great blocks. Contains *Orbitoides Mantelli* Mort., *Pecten Poulsoni* Mort., and numbers of casts. Rather large quartz grains disseminated through the bed .... 4 feet.
3. Blue glauconitic, sandy marl, containing *Pecten Poulsoni* Mort., *Discoflustrellaria Bouei* (G. and H.), *Turbinolia pharetra* Lea, and two species of Madrepora. 4 feet.

From this point down to Byram Station the strata are exposed continuously either on one bank or the other, so that the connection can be easily kept in sight. Half a mile below the last section the strata are exposed in a bluff half a mile long and running almost due south, thus affording an excellent opportunity for estimating the dip. For this purpose two hard ledges of Orbitoidal limestone five feet above the water were selected, and in three hundred yards they passed below the river level. Just around a bend, the river cuts across the strike, and, at this point, No. 2 of my section 3 has sunk nearly to the water's edge, which, as this point is three or four miles west of where the section 3 was made, shows a westerly inclination of six or seven feet to the mile. The resultant of these two dips shows a southwesterly dip. At Byram Station on the Illinois Central Railroad, ten miles from Jackson, the following section is exposed:

Section 5.

Surface soil .... 15 feet.

1. Reddish marl, containing a few grains of glauconite and numbers of *Pecten Poulsoni* Mort., and *Orbitoides Mantelli* Mort. .... 2 feet.

3luish gray marl, like the above, containing very little grit. Fossils—*Pecten Poulsoni* Mort., *Ostrea Vicksburgense* Con., *Cardium diversum* Con., *Crassatella Mississippiensis* Con., *Sigaretus Mississippiensis* Con., *Orbitoides Mantelli* Mort., *Cytherea imitabilis* Con., *Turritella Mississippiensis* Con., *Cytherea sobrina* Con., *Mitra conquisita* Con., *Turbinella protracta* Con., *Madrepora Mississippiensis* Con., *Cithara Mississippiensis* Con., *Arca Mississippiensis* Con., *Terebra divisura* Con., *Pleurotoma congesta* Con., *P. tenella* Con., *P.* (*Scobinella*) *cœlata* Con., *P. cristata* Con., *P. cochliaris* Con., *Aporrhais lyrata* Con., *Caricella demissa* Con., *Oliva Mississippiensis* Con., *Triton crassidens* Con., *T. abbreviatus* Con., *Solarium trilineatum* Con., *Ficus Mississippiensis* Con., *Capulus** *Americanus* Con., *Cyprea lintea* Con., *Phorus humilis* Con. .... 6 feet.

'he strata of this section overlie about twenty-five feet of te limestone which rests immediately upon the top of sec- 3. These marls are overlaid by white limestone, hard ;es of which are seen cropping out of the river bank below ferry at this point. The marl gradually sinks out of view, is entirely submerged, within a short distance below the y.

here is at Yazoo City an exposure sixty feet thick of gray areous clays which resemble very closely No. 1 of my ion 1. These clays contain *Ostrea pandœformis*† Gabb, *ericardia planicosta* Blain., *Pseudoliva perspectiva* Con., *Nu- magnifica* Con., *Natica permunda* Con., *Cytherea sobrina* . and *Zeuglodon cetoides* vertebræ.

hese observations, I think, establish beyond dispute the re- ›n of the Jackson beds to the Orbitoides limestone and marl ı of Byram station. The river, at the time, was at a very stage, affording excellent sections.

.s has been observed by Smith‡ the lower portion of Tuo- ·'s White Limestone in Alabama forms a stiff black prairie with a growth of hickory and oak. The upper portion, on other hand, is characterized by slightly undulating open ney woods" with numerous limesinks. The former, Jack- of Hilgard, is identified by *Spondylus dumosus* Mort.,

Rather a strange association; the species was described from Jackson and ıot before been found in Vicksburg strata.

›r. White (Fossil Ostreidæ of North America), says of this *Ostrea:* "It is ·ibed from the Cretaceous of Mississippi, but not having been figured it seems ıcticable to identify it." The fossil mentioned above answers very well to ı's description and is found in close proximity to the original locality. From ssociated fossils the strata are plainly Tertiary, though the black soil is apt to ·ad one.

}eol. Sur. Ala., 1881–82, page 236.

Ostrea Mortonii Gabb, and *Zeuglodon* vertebra, while the latter is recognized by the crystalline character of its limestone, as well as by its fossils, *Pecten Poulsoni* Mort. and *Orbitoides Mantelli* Mort. In Alabama this prairie soil invariably occurs north of these limesinks, and as a southern dip is everywhere recognized the natural inference is that the strata forming the prairie soils should underlie or be older than those forming the limesinks. I have observed these prairie soils in Clarke Co., Mississippi, near Shubuta, and east of that point crossing over into Alabama north of the boundary of Choctaw and Washington Counties. They continue from the Alabama line onward into north Washington County, to between St. Stephens and the line of Choctaw County. From this point they can be traced across Clarke County, always occurring north of the "limesink country," into Monroe County where the writer's investigations terminated.

At St. Stephen's Bluff on the Tombigbee River we have the following section:

1. Soft white limestone, the upper part containing numbers of *Orbitoides Mantelli* Mort., *Pecten Poulsoni* Mort., and a few *Scutella Rogersi* Mort., all of which become less frequent in the lower 20 feet, the lithological character remaining the same .... 75 feet.
2. Indurated ledge of blue argillaceous limestone containing *Ostrea eversa* Mellv. and large *Spondylus dumosus* Mort. on the under side of the ledge. Some of these *Spondyli* measure $3'' \times 2\frac{1}{2}''$ .... 6 feet.
3. Calcareous clay holding a few obscure fossils, mainly bivalves .... 4 feet.
4. Yellow glauconitic marl containing nodules of phosphate of lime and some few phosphatic casts—a *Conus*, several madrepores and *Ostrea Mortoni* Gabb, 15 feet.

This section was made at the old Spanish powder magazine. About a half mile below, at the steamboat landing, No. 4 sinks out of view showing a southern dip.

West of this bluff and at a greater elevation, the limestone becomes crystalline and shows in weathered masses above the surface in the Cedar grove covering the old town of St. Stephens, where the inhabitants call it "horse-bone" rock.

The Claiborne Ferruginous Sands (Smith) seem to become lignitic as we go west; for thirteen miles west of Bladon Springs, Choctaw County, the following section is exposed:

Surface soil and drift pebbles .... 3 feet.

1. Limestone somewhat argillaceous,—contains one or two hard ledges a foot or two thick—forms prairie soils—no fossils seen .... 40 feet.
2. Indurated limestone ledge full of fossil casts .... 2 feet.

3. Greenish black sandy clay with pockets of sand containing *Monoceros vetustus* Con., *Crepidula lirata* Con., *Voluta Sayana* Con., *Turritella vetusta* Lea, *Turritella Mortoni* Con., *Cardita planicosta* Lam., *Rostellaria velata* Con., *Corbula Murchisonii* Lea, *Corbula Alabamiensis* Lea, *Cytherea globosa* Lea, *Leda* sp.? .... 5 feet.

A careful examination of the fossils contained in the cabinet of the University of Mississippi failed to bring to light any fossils of this stratum (Ferruginous Sands). Through the courtesy of Dr. Geo. Little I was shown the section made by him along the course of the Chickasawhay River and I found nothing that in the least resembled this stratum. There are however several specimens of leaf impressions in a red shale labeled "Claiborne," for the age of which Dr. Hilgard must have relied upon stratigraphical data. The only representative of the strata showing at Claiborne Bluff is the "Ostrea sellæformis bed" (No. 6* of Aldrich) which occurs at Enterprise, eight miles southwest of Enterprise on Suanlovey Creek, and eight miles southwest of Decatur, Newton County.

In the railroad cut northeast of Enterprise occurs a light gray claystone having fucoidal impressions, just like the buhrstone at Lisbon, Ala. There is another exposure of the Lisbon strata in a railroad cut twenty-five miles west of Meridian, as follows:

Surface soil .... 2 feet.
1. Light gray sandy clays,—fossiliferous .... 12 feet.
2. Gray buhrstone with root-like impressions on upper surface .... 6 feet.

At Lisbon, Ala., a more careful examination has shown the "Scutella bed" (Smith) = *f* of O. Meyer's section,† exposed 140 feet above the river level, which confirms the connection between Lisbon and Claiborne.‡

These observations, it is hoped, will assist in establishing conclusively the relations of the Vicksburg, Jackson, and Claiborne beds.

Half a mile above the Upper Landing at Claiborne, Alabama, a rather interesting section is exposed in the road leading to the ferry. The section given is not one of the whole bluff, but of a small promontory on the roadside, showing however the relative positions of the underlying and overlying strata.

* This Journal, vol. xxx, No. 178, page 302.
† This Journal, vol. xxx, No. 175, page 69.
‡ This Journal, vol. xxx, No. 118, page 303.

SECTION ON FERRY ROAD, CLAIBORNE, ALA., WHITE LIMESTONE.

1. Scutella bed (*f* of O. Meyer's Claiborne Section) ... 18 inches.
2. Ferruginous sand,—somewhat more argillaceous than No. 4 and containing *Hipponix pygmea* Lea,* *Hippagus isocardiodes* Lea,† *Nucula Brogniarti* Lea, *Rostellaria velata* Con., *Astarte sulcata* Con., *Dentalium thalloides* Con., *Corbula Murchisonii* Lea, *Lunulites Bouèi* Lea, *Turbinolia pharetra* Lea, *T. Maclurii* Lea, *Flabellum Wailesii* Con.,‡ *Crassatella protexta* Con., *Scutella* sp. ?, *Ostrea Mortoni* Gabb, *Pecten Deshayesii* Lea, *Verticordia Eocensis*, sp. nov., *Avicula Clairbornensis* Lea, *Cytherea æquorea* Con., *Bulla galba* Con., *Bulla* (*Haminea*) *Aldrichii*, sp. nov., *Nucula ovula* Lea, *Venericardia parva* Lea, *Turritella lineata* H. C. Lea, *Turritella Mortoni* var. Con., *Solarium stalagmium* Con., *Erycina æquorea* Con., *Teredo* sp., *Pyramis sulcata* Con., *Obiliscus perexilis* Con., *Leda equalis* Con., two species of *Madrepora*, *Chiton* sp.? and the claw of a *Cancer* .... 3 feet.
3. Gray laminated clays irregularly interstratified with yellow sands. In the lower portion of the stratum are leaf impressions, and a variable streak of lignite which in places attains a thickness of two inches.... 8 feet.
4. Claiborne Ferruginous sands........................ 4 feet.

Indurated sandy ledge (1 of Aldrich).‡

No. 3 of this section seems to be developed only at this point, as across a gully not more than a hundred yards down the river the clays lose both their laminated and lignitic characters and the whole stratum becomes a mottled gray and red argillaceous sand which is non-fossiliferous; the ferruginous sands become about six feet thick. An examination of four or five other localities where the ferruginous sands are exposed failed to show any association with lignitic clays.

DESCRIPTIONS OF NEW SPECIES.

Verticordia Eocensis nov. sp.

Shell rotund, beak recurved, elevated and striate, substance of shell rather thick, lunule obscure, one prominent cardinal tooth, lateral teeth oblique, margin dentate and crenulated between dentations; nacre brilliantly pearly; muscular impressions two, profound; pallial line obscure; closely ribbed; ribs about 16, crenulate, radiating regularly from the beak and slightly recurved.

Length.... ·25 Breadth.... ·25 Height.... ·06

* This bed seems to be the natural horizon of these two fossils, for while they are very abundant here, they are seldom found in the ferruginous sands proper.

† Described from Jackson; has not yet been found in ferruginous sands but occurs occasionally in No. 1 of Aldrich's section.

‡ This Journal, vol. xxx, No. 178, page 302.

This, I believe, is the first *Verticordia* described from the Eocene, there having been only three species known among living and fossil shells, two of these being Miocene. Differs from *V. Emmonsii* Con., in being rotund and having more ribs, and from *V. cardiiformis* Wood in having no striations between the ribs, in being more rotund, and showing no incurving of the ribs as they approach the ventral margin.

Claiborne, Ala., and Jackson, Miss.

Bulla (*Haminea*) *Aldrichi*, nov. sp.*

Shell elongate oval, substance rather thin, punctate-striate, striæ about 20, transverse; spire involute; labrum sharp and slightly dentate; mouth longitudinal and rather larger at base than at top; columella very slightly thickened at the base.

Height........ ·2 Breadth........ ·1

Resembles *B. glaphyra* Desh., but differs in the striæ which are in *B. Aldrichi* from the top to the bottom, while in *B. glaphyra* Desh. they are confined to the upper and lower thirds of the shell.

These two species will be figured in the forthcoming Report of the Geological Survey of Alabama.

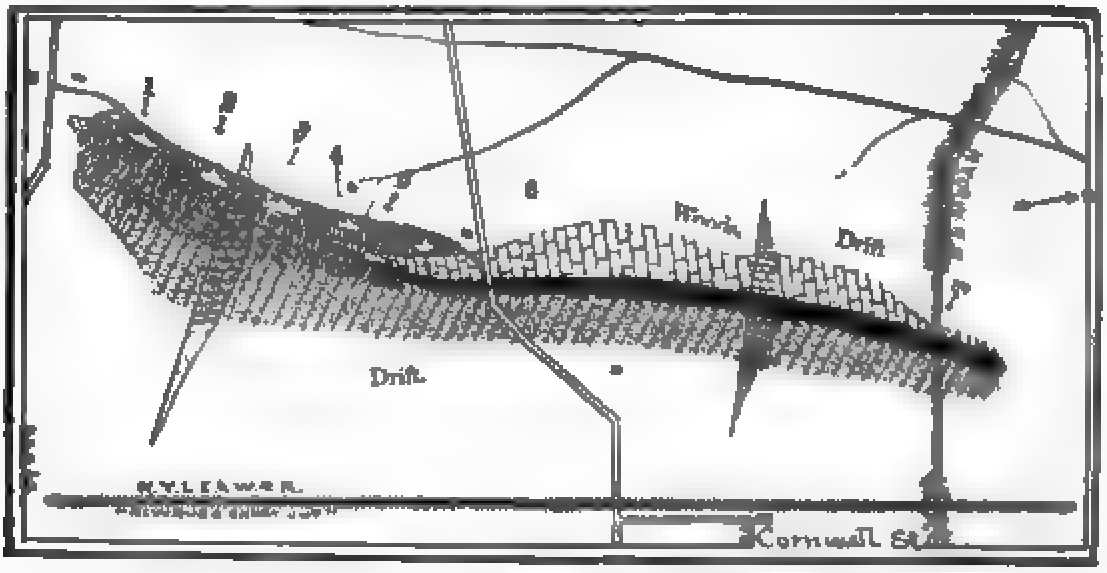
ART. XXI.—*On the Area of Upper Silurian rocks near Cornwall Station, eastern-central Orange Co., N. Y.;* by NELSON H. DARTON.

IN the course of a detailed examination of the formations other than Archæan in Orange Co., N. Y., the writer has made a careful study of the locality long known as the Townsend Iron Mine, and its vicinity, where, in a limited area, a small mass of Lower Helderberg limestone has been protected from the general denudation by a firm backing of coarse, strongly cemented sandstones; the whole forming a hill, passing a few meters west of Cornwall Station. Its more prominent geological features are shown on the accompanying map.

The occurrence of this series of fossiliferous strata, so far distant from the main mass of the formation to the north and west was first noted by Dr. Horton in the Report of the Natural History Survey of New York for 1839. On page 151, in a very general description there is the statement—"its apparent position is between the slate and grit-rock or Millstone grit of Prof. Eaton." The exact meaning of this is not entirely clear; Prof. Eaton's "Millstone grit" would in this instance be equiva-

* Named in honor of my friend, Mr. T. H. Aldrich, of Cincinnati, Ohio.

lent to the Oneida-Medina of the New York Survey, but the slate referred to may be that of Ordovician age immediately underlying, or of the slaty rocks of the various formations overlying the Lower Helderberg. Dr. Horton, however, considered



Upper Silurian area near Cornwall Station, Orange Co., N. Y.: Scale one metre =$\frac{1}{5}$mm. Blocked area, limestone; finely blocked, shaly limestone; dotted, sandstones and conglomerates; black, Water-Lime rock; simply lined, shales.

the slates of this district as the "Transition" argillite of Prof. Eaton, which is equivalent to the Primal slates of Prof. Rogers or the highest member of Dr. Hunt's Taconian series, which would make it appear possible that he had considered these limestones to be Potsdam or Trenton. In continuation, Dr. Horton states that the characteristic fossil is an "encrinite although many others occur." The associated grit rocks were considered Oneida-Medina, similar to others in the county.

Prof. Mather in his final Report, p. 362, agrees in this last, but states (p. 351) that the limestones belong to the Catskill shaly division and contain *Strophomena rugosa* and *S. radiata* in abundance. Dr. Horton's statements are quoted in full. Again, on p. 490, the limestones are referred to, and the opinion of their southward extension considered untenable. On p. 618, the dip is stated. Several sections of the district are given by Mather, one on plate 5 (fig. 13) is stated to be very imperfect in a note on p. 637, and one on plate 45 (fig. 1) is offered in its place. Another section on a larger scale, and of the mine alone, forms fig. 14 on plate 5, but is very incomplete.

In 1863, G. Dennison, in the Report of the New York Agricultural Society, notes the occurrence on the remarkable geological map of Orange County accompanying his paper. He also repeats the section by Mather last noted. In 1868, the locality was shown on the useful map accompanying the Geology of New Jersey by Prof. G. H. Cook. In 1878, Dr. T. S. Hunt referred to the locality and quotes Mather and Horton.*

* Azoic Rocks, Report E, 2d Geological Survey, Pa., p. 36.

ıe Transactions of the Vassar Bros. Inst., vol. ii, 1883–4, Professor W. B. Dwight reviews at considerable length servations of Horton and Mather and gives an account artial examination of the locality. He especially de- the small quarry to which I shall soon refer, but the imestone with its very varied fauna, and the fine expo- ı the railroad cut, besides others of lesser interest, are not He points out the succession of strata to be as fol- Oneida-Medina sandstones forming the eastern side of l overlaid southward by red shales possibly of Clinton ıd in the quarry, by the Tentaculite division of the Lime Group, the Lower Pentamerus and probably the l shaly. The iron ore is stated to be entirely superficial rived from the red shale and limestone at their contact. 885, J. C. Smock, in the Report of the Geological Sur- New Jersey for 1884 (p. 35) refers to the occurrence in tion with the discussion of the Devonian age of the Pond Mountain Series. Later in the same year, Darton s this last noted paper in the Scientific American Supt., nd reference is made to this area.

ıese several accounts and references, but little more than ·al statement of the prominent features are given and in or less disconnected manner, with the exception of the by Prof. Dwight. That such an insular area would very interesting results, when examined in detail, ap- very probable to the writer, and the following observa- ill, I trust, show that this opinion was well founded. ll composed of the formations under discussion rises ab- from the meadows and drift plains on either side, to a of about 35 meters. Its length is nearly a kilometer half and its greatest breadth 250 metres; the trend is –S.S.W. parallel to the strike of its rocks. The face is steep, in places precipitous, and exhibits an continuous outcrop of coarse red sandstones or conglom- with occasional intercalated beds of red shale. Toward thern termination, a mass of drift lies against the eastern early to its crest, but conglomerate outcrops at a low ear the end.

cementing material of these rocks is generally very ıs, the bedding heavy and irregular; the principal con- ts are more or less finely comminuted massive quartz, bles holding fossils were found on careful search. The ess of the strata varies from 15 to 30 meters, decreasing 'ard, and in the railroad cut shown on the map, the ng section is exposed, from east to west.

1. Sandstones, conglomerates and shales, interbedded..20 meters.
2. Arenaceous limestones thickly bedded and much fissured diagonally.............................. 7 "
3. Less impure more thinly bedded limestones. Upper members holding Water-lime fossils............... 5 "
4. Very fossiliferous, heavily bedded limestones holding Pentamerus and Delthyris shaly fossils ...... 5 "

These beds are very nearly vertical and strike N.N.E.; they graduate into each other almost imperceptibly; and 2 and 3 are considerably altered, holding in fissures and along bedding planes veins of quartz and iron oxides. In the upper members of 3, several remains of *Leperditia alta* were found. They were somewhat scattered and only fairly well preserved; detailed search in this and the adjacent beds failed to discover more. In a bed a few decimeters above, a mass of *Favosites Helderbergia* H. was found, and near by a *Zaphrentis Römeri* H., in a very poor state of preservation, but 40 mm. long by 30 in diameter.

In beds 4 the following species and individuals were found.

**Astylospongia inornata* H., many specimens; *Fenestella*, two forms; * *Chætetes Helderbergia* H., 1 specimen; **Favosites Helderbergia* H. and other *Favosites* sp.?; *Cladopora* sp.?; **Zaphrentis Römeri* H., 2; **Streptelasma stricta* H. 15 mm. long, 3; *Fistulipora* sp.?; Crinoidal remains; *Orthis oblata* H., 3; * *Orthis perelegans* H., 4; *Streptorhynchus Woolworthana* H., 2; **Strophomena rhomboidalis* Wahl., 23; **Spirifer cyclopterus* H., 9; **Spiriferina perlamellosus* H., 13; *Cyrtina Dalmani* H., 1; **Nucleospira ventricosa* H., 1; *Rhynchonella pyramidata* H., 2; *R. formosa* H.; **R. transversa* H., 1; *Meristella* sp.?; **Atrypa reticularis* Linn., 84; **Pentamerus galeatus* Dal., 176; **Platyceras Gebhardi* H., 1; *P. platystomum* H., 1. The names asterisked are of species occurring as complete individuals or impressions; and the others, of those found only in fragmentary valves, casts or impressions.

Although occurring at every point here, the *Pentamerus galeatus* is especially abundant in the more western bed exposed, where its water-worn valves literally fill some of the layers.

In their continuation southward, these strata are obscured by the drift which reaches quite to the summit on this part of the west side of the hill. But in a small quarry a few dozen meters south of the cross road, a fine exposure is found (at 5 on the map). The Water Lime rocks are exposed for a thickness of about a meter and the sandstone outcrops a few meters to the east. On one of the limestone layers remains of *Leperditia alta** occur in abundance associated with fragments of *Spirifera Vanuxemi* H.,* and indeterminable corals and crinoids; immediately overlying are beds holding the following remains:

* Also noted by Dwight.

Bryozoans, many; *Favosites Helderbergia* H.;* Corals and Crinoids; *Streptorhynchus Woolworthana*, H.;* (5) *Strophodonta variastrata* Con.; *Spiriferina perlamellosus* H.;* *Atrypa reticularis* Linn.;* *Pentamerus galeatus* Dal.;* *Orthoceras* sp.?†

These beds dip N. 65° W. >85 and a thickness of about four meters is exposed here.

Beginning at the cross-road and extending northward for several hundred meters, overlying beds are seen in the steep hill-side, and at 6 on the map the following remains were found.

Bryozoans, many; *Streptelasma stricta* H. (25^{mm} in length); *Orthis oblata* H., three casts; *Streptorhynchus Woolworthana*,* H., two valves; *Strophomena rhomboidalis* Wahl.,* fragments; *Spiriferina perlamellosus** H., four valves; *Meristella lævis* Con., one impression; *M. arcuata*, H., one cast.

Northward, these beds run under the drift; but southward they appear to be continued as thinly bedded, soft, shaly limestones, of light color, and superficially intercalating with beds of iron oxides which extend with them to the southern termination of the hill forming its western border. They are exposed only in the several open cuts from which the iron ores have been worked. In cuts number 3 and 4, the ore is entirely in this limestone; but in 2 and 1, the ore lies along the line of contact with a series of brown shales, a few meters in thickness which are separated by a considerable mass of bright red shales from the sandstones and conglomerates of the eastern side of the hill. These relations are shown in detail upon the map. The shaly beds yielded but one fossil after very thorough examination, and this was a section of a Crinoid stem showing no generic characters.

A notable feature of these beds, and of those of the shaly limestone, is an anticlinal fold along their extreme western border; the steep southeast dip abruptly changing to a gentle one in the opposite direction. The fold is first noticed in the entrance to cut 5, but it is finely exhibited in cuts 2 and 1 (see section on map), where the change is very abrupt and the shaly limestone but little disturbed; the brown shales in the east wall of both cuts show great disturbance. This fold appears to be a local crumple; it will again be referred to in a subsequent paper on the structure of the entire district.

The shaly limestone may extend out under the meadows on this side of the hill; the thickness in sight is about ten meters, including the ore beds. Wherever exposed, these strata contain characteristic Delthyris-shaly fossils; but in cut 2, on the western side of the fold, the finest specimens have been

* Also noted by Dwight.

† Dwight found a specimen recognizable as *O. longicameratum* H.

found, and in the greatest abundance. They all consist of casts or impressions and are preserved to perfection in a soft white or buff matrix of very fine grain and uniform texture. Their abundance is wonderful, and nearly all the individuals noted in the following table were found in half a cubic meter of shale. (Excavation is now necessary to expose this bed.)

It was considered desirable to ascertain the relative proportions of each of the species represented, and a count was kept until 500 individuals had been recognized, with the results given in the first column after the name; those noted in the second column were obtained at other times.

		Proportion in 500 Individuals.	Number of additional specimens collected.
1	2. Astylospongia inornata *H.*	5	3
2	1. Fenestella. Three forms.*	11	....
3	1. Several undetermined Bryozoans	18	....
4	3 Cladopora seriata *H.*	....	1
5	1. Crinoids, many fragments	....	....
6	2. Tentaculites elongatus *H.*	5	....
7	1. Discina discus *H.?*	....	1
8	1. Discina Conradi *H.*	1	....
9	3. Pholidops, two species, undetermined	16	13
10	3. Orthis oblata *H.*	128	....
11	1. Orthis tubulostriata *H.?*	....	1
12	2. Orthis emiuens *H.*	10	3
13	3. Orthis multistriata *H.*	4	1
14	1. Orthis resembling subcarinata *H.*	....	1
15	2. Strophodonta variastriata *Con.*	....	1
16	1. Strophodonta variastriata, var. arata *H.*	1	1
17	2. Strophonella Headleyana *H.*	23	....
18	2. Strophonella punctulifera *Con.*	9	....
19	2. Strophodonta Beckii *H.*	3	1
20	2. Streptorhynchus Woolworthana *H.*	20	....
21	2. Strophomena radiata *Vanuxem.*	2	....
22	2. Strophomena rhomboidalis *Wahl.*	83	....
23	2. Spirifer cyclopterus *H.*	4	....
24	3. Spirifer macropleurus *Con.*	91	....
25	3. Spirifer arrectus *H.*	....	1
26	3. Spirifer pyxidatus. H.	....	2
27	3. Spiriferina perlamellosus *H.*	20	....
28	1. Cyrtina Dalmani *H.*	2	....
29	2. Nucleospira ventricosa *H.*	....	1
30	1. Rhynchonella pyramidata *H.*	3	....
31	2. Rhynchonella formosa *H.*	5	....
32	3. Eatonia medialis *Vanuxem.*	10	2
33	2. Cœlospira concava *H.*	....	4
34	2. Cœlospira imbricata *H.*	3	2
35	2. Meristella lævis *Con.*	1	....
36	3. Meristella arcuata *H.*	21	....
37	2. Pterinea communis *H.*	....	1
38	3. Platyceras platystomum *H.*, et al. sp.?	3 + 2	2
39	3. Leperditia.	....	22

1. Represented by fragmentary valves, casts or impressions, etc. 2. Represented by complete valves, casts impressions, etc. 3. Worthy of special mention in notes following. * Including F. althea *H.*, F. arta *H.*

While the greater number of these species are characteristic f the formation at other localities, several are new to the forlation, others entirely new species, and some present other reaarkable features worthy of description; such will now receive iotice.

4. *Cladopora seriata* H. A fragment of this Niagara species ras recognized.

9. *Pholidops*. Represented by many casts and impressions, robably of two species, differing in several respects from the orms now known. They have been sent to Professor Hall for escription.

10. *Orthis oblata* H. Casts and impressions of this species 'ere very abundant, often finely preserved; considcrable variety f form is presented and every stage of growth.

13. *O. multistriata* H. Four ventral casts were found probbly of this spccies; two were of very young individuals, the thers finely developed. They differ from those figured and de-:ribed in Pal. of N. Y., vol. iii, by the entire absence of a sinus in ieir fronts which present a slight undefined elevation. The eaks are enormous, one cast 40×30^{mm} has an obtuse beak 7^{mm} in height and 9^{mm} wide at its base, which is distant 12^{mm} ·om the front; it is deeply lobed and slightly incurved. The ther cast is 33×25^{mm}, the very obtuse beak 13^{mm} in height and 2^{mm} wide at its base which is distant 12^{mm} from the front.

24. *Spirifer macropleurus* Con. Every stage of growth and 'ariety of form is presented in the abundant casts of this pecies; nearly four-fifths of these were of ventral valves. Some ndividuals were very large, casts 70×60^{mm} are common. I ound one 90^{mm} wide and 40^{mm} long, but it is somewhat dis-;orted. Many magnificent specimens were observed.

25. *S. arrectus* H. This Oriskany species was represented by a ventral cast found in the eastern side of the anticlinal and there associated with many of the above noted species.

28. *S. pyxidatus* H. Another Oriskany species, of which a dorsal cast and ventral impression were found.

27. *Spiriferina perlamellosus* H. Very abundantly repreiented by casts and impressions often of very large size.

32. *Eatonia medialis* Vanux. Several very complete casts of individuals of large size were found, one 40×32^{mm}.

36. *Meristella* (*arcuata?*) H. This species is comparatively .bundantly represented by ventral casts presenting considerable 'ariety of form and generally very transverse; one found is 50^{mm} wide and 35^{mm} long. The beaks are greatly incurved.

38. *Platyceras platystomum* H. Several varieties of this form were found, one very similar to fig. 1, plate 61, of vol. iii, Pal. of N. Y.

39. *Leperditia*. A small species differing from any now known and represented by numerous casts and impressions about $2{\cdot}5^{mm} \times 1{\cdot}5^{mm}$. They have been sent to Professor Hall for description.

While many other species presented minor features of interest, their description would enlarge this paper beyond its scope. Briefly stated, in conclusion, in this overturned series the sandstones, conglomerates and shales are undoubtedly of older age than the limestones, but I am not inclined to assign them to any definite formation, out of consideration of their isolation. They may be more or less nearly equivalent to the Medina beds as exhibited in the Shawangunk Mts. The limestones immediately overlying, are without doubt equivalent to the Water-lime division, and these are in turn overlaid by limestones carrying a mixed Pentamerus and Delthyris-shaly fauna, the uppermost members of which in their southern extension are superficially decomposed and impregnated with iron ores, and they contain an abundant fauna, including some species of lower divisions, together with some formerly restricted to higher horizons.

The relations of these formations to others in the district will be discussed in a subsequent paper.

Finally the writer wishes to acknowlege his great indebtedness to Professor R. P. Whitfield for his kindly aid and advice, without his assistance many of the more obscure species would not have been recognized. To Professor Hall I am likewise indebted for aid in the determination of obscure forms and for other favors.

To my aids, Messrs. F. Marshall Smith and Wolcott Foster, I am also under obligations.

Washington, D. C.

SCIENTIFIC INTELLIGENCE.

I. Physics and Chemistry.

1. *On the Dilatancy of Media composed of rigid particles in contact.*—Notwithstanding the many hypotheses of matter, it does not appear that any attempts have been made to investigate the dynamical properties of a medium consisting of smooth hard particles held in contact by forces transmitted through the medium. Osborne Reynolds has pointed out the existence of a singular fundamental property of such granular media, which is not possessed by known fluids or solids. To this unique property of granular masses he gives the name "dilatancy" because the property consists in a definite change of bulk consequent on a definite change of shape or distortional strain; any disturbance whatever causing a change of volume and generally dilation. In the case of fluids, volume and shape are perfectly independent. But with granular media, the grains being sensibly hard the case

is entirely different. So long as the grains are held in mutual equilibrium by stresses transmitted through the mass, every change of relative position of the grains is attended by a consequent change of volume; and if in any way the volume is fixed, then all change of shape is prevented. Thus a group of equal spheres being so arranged that if the external spheres are fixed, the internal ones cannot move, any distortion of the boundaries will cause an alteration in the mean density depending on the distortion and the arrangement of the spheres. If a canvas bag contain hard grains or balls, so long as the bag is not nearly full it will change its shape as it is moved about; but when it is approximately full a small change of shape causes it to become perfectly hard. If instead of a canvas bag, an extremely flexible bag of india rubber be filled with heavy spheres (No. 6 shot), the envelope imposes no sensible restraint on their distortion; so that when standing on the table it takes nearly the form of a heap of shot. But if the interstices between the shot be filled with water so that the bag is quite full of water and shot, no bubble of air being contained in it, and the mouth be carefully closed it will be found that the bag has become absolutely rigid in whatever form it happened to be when closed. Since neither the envelope nor the water imposes any distortional constraint on the shot, what it is which converts the heap of loose shot into an absolutely rigid body? Clearly the limit which is imposed on the volume by the pressure of the atmosphere. So long as the arrangement of the shot is such that there is enough water to fill the interstices, the shot are free; but any arrangement which requires more room is absolutely prevented by the pressure of the atmosphere. The existence of dilatancy in sand explains the well marked phenomenon observed in walking on a wet beach. As the foot falls on the sand, it whitens or appears momentarily to dry around the foot. When this happens the sand is full of water, the surface of which is kept up to that of the sand by capillary attraction. The pressure of the foot causes dilation of the sand and more water is required which has to be obtained either by depressing the level of the surface against the capillary attraction or by drawing water through the interstices of the surrounding sand. The latter requires time to accomplish; so that for a time the capillary forces are overcome, the surface of the water is lowered below that of the sand, leaving the latter dryer until a sufficient supply has been obtained from below. On raising the foot it is generally seen that the sand under the foot and immediately around it is wet; because the distorting forces being removed the sand again contracts and the excess of water finds momentary relief at the surface. In the opinion of the author the recognition of this principle of dilatancy places a hitherto unrecognised mechanical contrivance at the command of those who would explain the fundamental arrangement of the universe, and one which seems to promise great things. For example, hitherto no medium has ever been suggested which would cause a statical force of attraction between two bodies at a

distance. Such attraction would be caused by granular media in virtue of this dilatancy and stress. More than this, when two bodies in a granular medium under stress are near together the effect of dilatancy is to cause forces between the bodies in very striking accordance with those necessary to explain coherence of matter. So far as the integrations have been carried, it appears with a certain arrangement of large and small grains that the forces between the bodies would be proportional to the product of the volumes divided by the square of the distance; i. e., that the state of stress of the medium may be the same as Maxwell has shown must exist in the ether to account for gravity.—*Phil. Mag.*, V, xx, 469, Dec., 1885. G. F. B.

2. *On the use of the Induction Spark in Spectrum work.*—In noticing Lagarde's research on the hydrogen spectrum, E. WIEDEMANN has criticised the results obtained, since the induction spark was used as a source of electricity. Hence the numerical values given in his paper have no exact significance and furnish only a general idea of the phenomena. It is a well known fact that the discharge of an induction coil is a complex phenomenon, the primary discharge being followed by a series of partial discharges with decreasing intensity. Hence if the induction spark be used to produce spectra, the intensity and character of these spectra change with each partial discharge, one of these discharges producing perhaps a line spectrum while another gives rise to a band spectrum. But the effect upon the eye is even more complex. It is not the sum of the impressions which is observed, since the diminution of visual sensitiveness with time is felt in a very different manner when the discharges are of different intensities. It is true that the Holtz machine is not so ready a means of supplying the spark as the induction coil. But that difficulty is more than counterbalanced by the accuracy of the results obtained with it. To prove that in Lagarde's method there were partial discharges to a marked degree added to the principal one, the author constructed a tube of the same dimensions as that used by him, and examined the character of the induction spark within it by means of a revolving mirror. In place of seeing a single line, a long luminous band was visible corresponding to a great number of partial discharges. —*Ann. Chim. Phys.*, VI, vii, 143, Jan., 1886. G. F. B.

3. *On the Vapor-pressures of Mercury.*—The great importance of an accurate determination of the pressures of mercury vapor at different temperatures, and the fact that the values given by Regnault and hitherto relied upon, are regarded by him as only approximations, has led RAMSAY and YOUNG to experiment in this direction with an improved apparatus. It consisted of a U-tube connected with a manometer and enclosed in a jacket containing the substance whose boiling point gave the temperature. The U-tube was filled with mercury and boiled to expel air. On heating it and diminishing the pressure by means of a pump, vapor was evolved from the mercury depressing the level on one side and raising it on the other. From the differ-

ences of level in this tube and in a manometer gauge connected with it, the vapor pressure was calculated. The temperatures chosen were the boiling point of methyl salicylate under atmospheric pressure; of bromonaphthalene under a pressure of 612·8^{mm}; of the same under a pressure of 756·2^{mm}; of mercury and of sulphur. The temperatures corresponding were 222·15°, 270·35°, 280·6°, 358·47° and 448°. The vapor pressures observed were 34·4, 124·35, 157·15, 767·43, 2904·5 millimeters. The authors having shown that if a diagram be constructed in which the ratios at the same pressure between the heats of vaporization of two liquids at various pressures the same for both, form the abscissas, and the absolute temperatures of one of the two liquids corresponding to these vapor pressures, form the ordinates, then the points representing the relations between these ratios and the absolute temperatures will lie in a straight line—constructed the curve from the above data, combined with the absolute temperature of water required to give the above vapor pressures, and found it to be a straight line. By its means, other desired values were interpolated and a complete table of vapor pressures obtained for mercury and water between 135° and 520°. A second table is also given, in which the vapor-pressures are calculated for each degree centigrade; enabling the temperature of mercury vapor when used in a jacket, to be ascertained from the observed pressure.—*J. Chem. Soc.*, xlix, 37, Jan., 1886. G. F. B.

4. *On the limits of the conversion of Sodium carbonate into Sodium hydrate by means of Lime.*—LUNGE and SCHMID have investigated the conditions of concentration, temperature and pressure under which the maximum conversion of sodium carbonate is effected by means of caustic lime. Solutions of pure sodium carbonate of different degrees of concentration were heated to boiling for an hour in an iron vessel with an excess of lime, at the ordinary atmospheric pressure. Other similar solutions were similarly treated in copper tubes for the same time, continual agitation being secured by means of a stone placed inside. After the operation the solutions were analyzed; the total alkalimetric titer being effected with methyl orange as an indicator, and the sodium hydrate determined by Winkler's method (addition of barium chloride and phenol-phthalein and titering with oxalic acid till the color disappears). As a result, it appears that at ordinary pressures, for solutions containing 2, 5, 10, 12, 14, 16 and 20 per cent of carbonate, 99·4, 99·1, 97·3, 96·5, 95·0, 93·8, and 90·9 per cent respectively of the sodium had been converted into hydrate by this treatment. At high pressures, and at temperatures varying from 148° to 153°, for solutions of 10, 12, 14, 16 and 20 per cent of carbonate, 97·3, 96 6, 96·1, 95·1 and 91·6 per cent of the sodium was in the condition of hydrate. These figures show that there is no special advantage in heating under high pressure; a fact confirmed on the large scale by Jurisch who heated a mixture of specific gravity 1·157 to 1·177 for six hours under a pressure of three atmospheres and

obtained from 90·6 to 91·9 per cent of the sodium in the form of hydrate.—*Ber. Berl. Chem. Ges.*, xviii, 3286, Jan., 1886. G. F. B.

5. *On the Phenol constituents of Blast Furnace tar.*—A preliminary examination of a coal tar obtained from the Gartsherrie iron furnaces in which Scotch coals of low grades are used, showed that the oils of higher boiling point contained more compounds absorbable by acids and less phenol constituents absorbable by soda, than the oils boiling below them. WATSON SMITH, aided by Messrs. COUTTS and BROTHERS have examined these lighter oils in order to ascertain the proportion of phenol-constituents, by treating them with soda solutions of progressively increasing density, decanting and liberating the phenols by an acid. In this way 23·1 per cent of these substances were obtained from the oils. With regard to the basic constituents 1160 c.c. of the tar oils were shaken for a day with 840 c.c. dilute sulphuric acid of about 1·2 sp. gr. After 12 hours the acid was removed, neutralized with soda and salt added, and the whole allowed to stand in a graduated jar. The volume of basic bodies was read off and they were then dissolved in ether, the ether decanted and evaporated. In this way 150 c.c. crude bases or 11·09 per cent were obtained. This richness in phenols is exceptional, and far exceeds the yield of ordinary coal tar. The crude phenols were fractionated and it appeared that only 5·63 per cent distilled over between 180° and 210°, while 30 per cent passed over between 210° and 240°, and 18 per cent between 260° and 300°. The fractionings were repeated and the products classified as A, boiling below 230°; B, between 230° and 300°; and C, above 300°. On examination of A, the product boiling between 180° and 185° was phenol and readily solidified in a freezing mixture, melting again at 3°. With it boiling between 180° and 200° were cresols. The portion passing over between 210° and 225° was distilled over hot zinc dust and gave a mixture of xylenes with a little toluene; showing that the original material was xylenol, mixed with some cresol. Group B when similarly treated yielded trimethylbenzene, showing the original phenol to have been pseudocumenol; and naphthalene derived from naphthol present. Group C yielded naphthalene on distillation over zinc dust and a yellowish mass of the consistence of butter which is reserved for further examination.—*J. Chem. Soc.*, xlix, 17, Jan., 1886. G. F. B.

6. *On the presence of Raffinose in Barley.*—O'SULLIVAN has submitted to examination some crystals obtained several years ago from barley and at that time labeled "sucrose from barley." Under the microscope they were elongated flattened prisms terminated by a dome parallel to the shorter axis, the crystals radiating from a center. Optically, one specimen gave $[\alpha]_j = 125°$ and another $[\alpha]_j = 114°$. On solution, filtration, and the addition of alcohol, the liquid was filled with radiating groups of beautiful silky crystals, well defined rhombic prisms, having a brachydome. On recrystallization the crystals gave $[\alpha]_j = 134° - 135°$, and their

nalysis corresponded to the formula $C_9H_{16}O_8$ for the anhydrous ody. Calculated with the water lost on drying in a vacuum ver sulphuric acid, the complete formula is $C_9H_{16}O_8(H_2O)_{2\frac{1}{2}}$ or $C_{18}H_{32}O_{16}(H_2O)_5$ if doubled. These results leave no doubt that his sugar is raffinose and therefore establish the presence of this ugar in barley.—*J. Chem. Soc.*, xlix, 70, Jan., 1866. G. F. B.

7. *Elements of Inorganic Chemistry;* by JAMES H. SHEPARD. 77 pp. 8vo. Boston, 1885, (D. C. Heath and Co.)—This little ook is simple in method and style and aims to instruct the stulent by leading him to verify the chemical principles by actual exeriment; faithfully carried out with a judicious teacher it ought o produce good results.

8. *Chemical Problems*, by Dr. KARL STAMMER; translated from he second German edition with explanations and answers, by W. 3. Hoskinson. 111 pp. 8vo. Philadelphia, 1885 (P. Blackiston, Son & Co.)—The teacher who finds his ingenuity taxed to provide numerical problems for his class in chemistry will find assistance in this collection. The problems are simple and are arranged nder the successive elements, twenty-seven of these being seected; the variety is not very great, and might perhaps have een advantageously increased.

II. GEOLOGY AND MINERALOGY.

1. *Bottom deposits from dredgings under the supervision of* ALEXANDER AGASSIZ; by the Coast Survey Steamer Blake, Lieut.-Commander C. D. SIGSBEE, U. S. N., and Commander J. R. BARTLETT, U. S. N., commanding. *Report on the specimens*, by JOHN MURRAY. Bull. Mus. Comp. Zool., vol. xii, No. 2, Oct., 1885.—The following are some of the facts from this important paper. To the results from the dredging of the "Blake," Mr. Murray, of he Challenger Expedition, has added others by way of comparison from those of the "Challenger."

(1.) *Gulf of Maine, and Atlantic border, southward to Cape Hatteras.*—The bottom deposits from the region between the coast and the inner edge of the Gulf Stream, where the greatest lepths found were 1394 and 1186 fathoms (8364 and 7116 feet), are chiefly continental debris, 80 to 85 per cent consisting of mineral articles and clay—the former, quartz, feldspars, magnetite, hornlende, augite, mica, tourmaline, with occasional glauconitic rains. In latitude 38° 34′ N., the "Challenger" dredged up, in 1240 fathoms (7440 feet), pebbles of quartz, common and feldsathic quartzytes, mica schist, serpentine and compact limestone, one above 6 or 7 cm. in diameter. In 39° 43′ N., the "Blake" rought up similar pebbles, but much larger and some of them laciated; and in 41° 14′ N., the depth 1340 fathoms (8040 feet), he "Challenger" dredged similar rock fragments, with one block of yenite weighing five hundred pounds. The region is within the nfluence of the Labrador current and the material is "regarded as chiefly ice-borne."

Only a small proportion of the material is of organic origin. "The siliceous remains of Diatoms, Radiolarians and Sponges, together with arenaceous Foraminifera and glauconitic casts of Foraminifera, make up sometimes 4 or 5 per cent. of the deposit. In 41° 13′ 53″ N. and 65° 57′ 25″ W., the depth 810 fathoms (4860 feet), there were 5·08 per cent of calcareous material consisting of Coccoliths, Coccospheres, fragments of Echinoderms (these including a few pinnules of Crinoids), and a dozen Foraminifera of which the Pelagic kinds included *Globigerina bulloides*, *G. inflata*, *G. Dutertrei*, *Pulvinulina Menardii*, *P. Micheliniana* and *P. Canariensis*, and the Bottom-living species were *Haplophragmium Canariensis*, *Textularia* —— ? *Bulimina marginata* *Uvigerina pygmæa*, *Truncatulina lobata*, *ula* and *Pulvinulina elegans*. The rest of the bottom material was a mud of mineral character, partly argillaceous, containing Diatoms, Radiolarians, and spicules of sponges. In another dredging in 41° 34′ 45″ N. and 65° 35′ 30″ W., the depth 1242 fathoms (7452 feet), the calcareous portion was 7·25 per cent of the whole. Nearer the coast, in 466 fathoms (2796 feet), 39° 50′ 45″ N., 70° 11′ W., the gray mud was similar to the last and contained 3·46 of calcareous material. Again at a greater depth, 1394 fathoms (8364 feet), the gray mud was plastic and contained 16·81 per cent of calcareous material; 40 per cent of mineral grains, that is as above stated of quartz, feldspars, mica, hornblende, magnetite, olivine, glauconite, glassy fragments; 5 per cent of Diatoms, Radiolarians and Sponge spicules, and 38·19 per cent of argillaceous nature with fragments of siliceous organisms.

(2.) *Between Cape Hatteras and Lat.* 31° 48′ *N.*—The materials brought up from depths under 1000 fathoms (with two exceptions) were green muds or sands, and were situated beneath the Gulf Stream or along its inner margin. The mineral particles in the mud are like those north of Cape Hatteras, but finer (seldom exceeding 0·4mm. in diameter) and evidently have not been transported by ice; they consist of quartz, feldspar, augite, hornblende, magnetite and a few fragments of glassy rocks. There is frequently an abundance of glauconitic grains and also grains of manganese peroxide. 50 per cent or more of the deposit is usually calcareous, consisting of dead shells of pelagic Foraminifera and Mollusks, fragments of Echinoderms, Bryozoa and Coccoliths. All the tropical species of pelagic Foraminifera occur here while rare north of Hatteras; 10 or 12 p. c. consist of siliceous organisms, as Diatoms, Radiolarians, Sponge-spicules and glauconitic casts of Foraminifera, etc. The finer washings are greenish owing to some material not yet investigated, like those obtained by the "Challenger" from similar depths on the coasts of Africa, Australia, Japan and China. Many of the deposits might be called Globigerina oozes. Besides these materials there are concretions of calcium and manganese phosphate everywhere; and one such from a depth of 333 fathoms, in 31° 57′ N. and 78° 18′ 35″ W., from over a hardish bottom, was nine inches

n its longer diameter and mottled with black, red and brown colors. It was overgrown with sponges, corals and annelids. Imbedded in the concretion were two Sharks' teeth resembling those of Lamna, the largest $2\frac{1}{4}$ in. long and 1 in. across the base. Mr. Murray says that "this tooth is similar to many found by the "Challenger" in great numbers in the greater depths of the central Pacific, frequently forming the centers of manganese nodules;" but while those of the Pacific always had the interior removed, the vaso-dentine of these teeth was well-preserved, as in the fossil specimens of South Carolina and Malta. This concretion has a brecciated character; the fragments were cemented by calcium carbonate and manganese oxide, the latter everywhere penetrating the mass; and in the mass were remains of pelagic and other calcareous Foraminifera, of Pteropods, and fragments of Echinoderms, with many small, rounded glauconite-like phosphatic grains. Very similar masses were dredged by the "Challenger," especially off the Cape of Good Hope but also elsewhere. Phosphatic nodules were found in depths less than 1500 fathoms, but not in deeper deposits far removed from land. The above concretion, analyzed by M. Klement, afforded Phosphoric acid 23·53, carbon dioxide 15·56, sulphur trioxide 2·29, fluorine 2·28, chlorine 0·16, lime 52·15, magnesia 1·01, loss on ignition 3·15, insoluble residue 0·52=100·65.

At a depth of 457 fath. (2742 ft.) in 33° 19′ N., 76° 12′ 30″ W. (bottom temperature 40° F.) a greenish coherent mud was obtained, 59·43 p. c. of which were calcareous; of the mud, 20 p. c. were mineral grains, quartz, hornblende, feldspars, glauconite and glassy fragments; 5 p. c. were siliceous organisms, Diatoms, Radiolarians, Sponge-spicules; and 15·57 were argillaceous material, with Diatoms, Sponge-spicules and fine mineral particles.

The calcareous Foraminifera included (those that were common are marked with an asterisk) (*a.*) Pelagic : **Globigerina* (*Orbulina*) *universa*, **G. bulloides*, *G. conglobata*, **G. bulloides* var. *triloba*, *G. æquilateralis*, *G. sacculifera*, **G. dubia*, **G. rubra*, **Cadeina nitida*, *Sphæroidina dehiscens*, **Pullina obliquiloculata*, **Pulvinulina Menardii*, **id.* var. *tumida*, **id.* var. *fimbriata*, *P. Micheliniana*, *P. Canariensis*; (*b.*) Bottom-living species: *Biloculina ringens*, *Miliolina seminulum*, *Bulimina marginata Polymorphina* —— ?, *Uvigerina pygmæa*, **Sphæroidina bulloides*, *Pullinia sphæroides*, *Truncatulina lobatula*, T. —— ?, *Nonionina umbiliculata*, *Nodosaria communis*, *N. lævigata*.

(3.) *Off the shores of the Greater and Lesser Antilles.*—The dredgings were rather near the coasts and at various depths to over 2000 fathoms, but mostly under 1000. The mineral particles were chiefly from volcanic rocks; a few only were from other rocks of the species quartz, tourmaline, mica, epidote; glauconite and phosphate grains were rare. The percentage of calcareous material was high, frequently 70 or 80 p. c. (in one case, 90·24 p. c.) except where the shores were of volcanic rocks without reefs, and here they were volcanic muds. For the most part they

should be termed Pteropod and Globigerina oozes, though differing from these oozes of the open ocean in the size and nature of the mineral particles.

The siliceous organisms never make up more than 4 or 5 per cent of the whole, and consist of Radiolarians and Sponge-spicules with a few Diatoms. Off the Barbadoes in 221 fathoms was obtained a calcareous concretion two inches in diameter; it was formed about shells of Foraminifera, etc., each acting as a separate center. Off Northern San Domingo, in 772 fathoms (4632 ft.) small manganese nodules (the largest 2 in. in diameter) were obtained, the interior of which consisted of cemented pelagic Foraminifera; they resembled nodules dredged by the "Challenger" in 1525 fathoms near the Cape Verdes.

In the Old Bahama Channel, at a depth of 438 fathoms (2628 ft.), the bottom was a Pteropod ooze or white coral mud; 87·06 per cent. were calcareous, consisting of shells of Gasteropods, Lamellibranchs, Pteropods and Heteropods, Ostracoids, calcareous Algæ, Bryozoans, fragments of Echinoderms, Alcyonium spicules, coccoliths, Rhabdoliths, and about thirty species of Foraminifera. Three per cent were siliceous organisms, 6·94 per cent argillaceous, 12·94 mineral grains.

West of Navassa Bank, at a depth of 1050 fathoms (6300 ft.), the bottom (temp. 39½° F.) was a Globegerina ooze, 62·38 per cent being calcareous, and mostly made up of Foraminifera, with shells of Lamellibranchs, Pteropods, Heteropods, Coccoliths and Rhabdoliths, four per cent consisted of siliceous organisms.

Off Porto Rico, in 874 fathoms, (5244 ft.), the bottom was a coral or Pteropod ooze, 70·66 per cent being calcareous, and seven per cent of siliceous organisms. No coral fragments are mentioned as having been found.

Off Santa Cruz, depth 2375 fathoms (14,250 ft.), the bottom was a Globigerina ooze, 63·54 per cent being calcareous; 11·46 argillaceous; mineral grains (including fragments of mica schists 3 to 5^{mm} in diameter, feldspars, quartz, mica, hornblende, magnetite); and five per cent siliceous spicules of sponges.

Off Dominica, depth 1131 fathoms (6786 ft.), the deposit was a volcanic mud, with 13·78 per cent calcareous material and consisting of Pteropods, Echinoderm fragments, Coccoliths and Foraminifera. Off Martinique, in 1224 fathoms (7344 ft.), the bottom was a volcanic mud, of which 13·41 were calcareous and included Otoliths of fishes, Pteropods, fragments of Echinoderms, Coccoliths and Foraminifera (20 species), and three per cent siliceous organisms. Off Grenadines, in 163 fathoms (998 ft.), a yellowish brown Pteropod ooze was dredged, with 76·20 per cent calcareous and containing 30 species of Foraminifera. Off Barbadoes, in 218 fathoms (1308 ft.), the bottom (temperature 52½° F.) was a Pteropod ooze or Foraminiferal sand, 38·09 per cent calcareous, and 25 per cent siliceous (many Sponge spicules with a few Diatoms and one or two Radiolarians, and glauconite).

(4.) *Gulf of Mexico and Florida Straits.*—Under 100 fathoms,

the deposits vary with the kinds of coasts; and beyond 100 fathoms, they are still determined largely by the greater or less proximity to the embouchures of rivers or to coral reefs. Throughout the region the mineral particles (not calcareous) seldom exceed $0 \cdot 1^{mm}$ in size and they appear to be wholly derived from the rivers of the continent. The calcareous portion consists mostly of pelagic Foraminifera and shells of Mollusca. In depths beyond 2000 fathoms, Pteropod and Heteropod shells appear to be nearly if not quite absent, the calcareous material being Foraminiferal; but in less depths they are common; and between the 200 and 500 fathom lines, they make in many places the chief part of the deposits. In some places the deposits are chalk-like. Of Radolarians and sponge spicules, only three per cent.

In the Florida Straits there are interesting phosphatic concretions. In one Mr. Klement found 33·42 per cent of phosphoric acid, with 5·80 carbon dioxide, 2·74 sulphur trioxide, 51·90 of of lime, magnesia 0·70, iron and alumina 1·56, fluorine 1·21, insoluble residue 0·21, loss on ignition 2·16, with traces of silica and chlorine. The presence of so much fluorine in this and the other concretion analyzed by Mr. Klement is an interesting fact. Mr. Murray observes that "that there are difficulties in understanding how calcium phosphate and calcium carbonate are deposited at the bottom of the sea, yet there is no doubt that such a deposition does take place under some special circumstances. Their solution in the ocean water is an almost universal phenomenon."

2. *Törnebohm on the formation of quartzite by enlargement of the quartz fragments of sandstone;* by R. D. Irving.—In recent publications on this subject (Bulletin No. 8, U. S. Geological Survey, and Fifth Annual Report, U. S. Geological Survey) I have attributed to Sorby the first recognition of the process of enlargement of quartz fragments, which we now know to have been well nigh universal in quartzose fragmental rocks; while at the same time showing that several others, including myself, had independently observed such enlargements. Recently my attention has been drawn to the existence of a paper by Törnebohm dating as much as three years before that of Sorby, in which an account is given of a red quartzite from Dalecarlia, Sweden, formed by this process of enlargement from a sandstone. This paper (Geol. Förens. i Stockholm Förh., iii, 217), the original of which I have not yet been able to see, is reviewed in the Neues Jahrbuch für Mineralogie for 1877, p. 210; and the statements of the reviewer, evidently reproducing those of Törnebohm, read very like some in my own publications. After saying that the thin section, as seen in ordinary light, shows the fragments sharply outlined by oxide of iron borders, the reviewer says that in the polarized light, "the borders of the fragmental grains are hardly any longer recognizable; the rock appears as though it were a crystalline aggregate of irregularly angular quartz grains, exactly fitting one another, just as is the case with the quartzites

in general." The cementing silicic acid has divided itself off into areas each of which has attached itself to one of the original fragments, forming with it "a crystallographically single individual. Thus the quartz grains enlarged themselves until they mutually limited one another, and filled out all interstitial space, so that their form naturally became that of irregularly angular grains. The original form of the quartz grains is only now recognizable by the dust upon their surfaces; without this dust the elastic nature of the rock would be completely obliterated, and the whole appear as a crystalline granular quartz-aggregate."

It does not appear from this review that Törnebohm was disposed to extend these conclusions to all ordinary quartzites, or that he appreciated the similarity of origin of the quartzites and so-called "crystallized" sandstones.

Washington, D. C., January 28th, 1886.

3. *A Submarine Crater in the Atlantic near the Canaries.*—In a paper of much interest on "The North Atlantic as a Geological Basin," by T. Mellard Reade (Presid. address to the Liverpool Geol. Soc., 20 pp. 8vo, 1885), we find it stated, from information received by Mr. Reade from Sir James Anderson, that the inequalities of the bottom are very great between Lisbon and the Canary Islands; that "off the Burlings we found a crater nearly 1,000 fathoms deep, into which the cable [electric] ran, and we had afterwards to recover and re-lay it; on the top of the crater were 80 fathoms soundings." "The depression is only a few miles in diameter," while "all around it is under 100 fathoms." Valleys are abundant; "off the Burlings, 39° 25′ 30″ N. and 9° 54′ W., the ship had 1,300 fathoms under her bow and sounding under the stern they got 800 fathoms." "Off Lisbon and up to the edge of the soundings there are great inequalities, which no doubt are due to a chain of mountains in the ocean. The problem we have to solve when the cable is laid over such places is by numerous soundings to trace out the valleys. Sometimes we succeed, but sometimes we do not, as often within half a mile there are great inequalities, and it would be impossible to sound the whole ocean every half mile." From these and other facts maintained in his paper, Mr. Reade concludes that the ocean's bottom is not as even in surface or gentle in its slopes, as announced in some recent descriptions.

4. *Geological Sketch of the Island of Antigua;* by E. C. Purves. (Bull. Mus. Roy. d'Hist. Nat. de Belgique, Brussels.)—This paper is accompanied by a colored plate and section showing successive formations from southwest to northeast, the general trend of them being northwest. They are, commencing to the southwest: (1) various volcanic rocks, in hills 800 to 1200 feet high; (2) Upper tufas which he proves to be of Miocene age, with (*a*) Lower marine limestone with chert, (*b*) volcanic, sand and conglomerate, and (*c*) chert, of freshwater deposition; (3) Upper limestone and marls with hills of 300 feet, and with a narrow sea-border in part of recent horizontal marls. No. 1 and

3 have a width of two to four miles, and 2 of $2\frac{1}{2}$ to 4 miles. There is also a hill (Drews Hill) of trachydoleryte near the central line of the island which is spoken of as a volcanic hill. The Lower marine limestone contains shells and fossil corals. Among the corals Prof. Duncan identified *Alveopora dædalea* and *Stylocœnea lobato-rotundata* Mich., the latter a species occurring in the lower limestone of Malta and elsewhere, and Mr. Purves adds *Prionastræa diversiformis* Mich., *Solenastrœa Turonensis* Mich., *Porites Collegnana* Mich., all Miocene species. The *Alveopora* is a living Red Sea species. *Orbitoides Mantelli*, recognized by Prof. T. Rupert Jones from the chert of Antigua, Mr. Purves found in the upper limestone and not in the marine chert; and he adds that this foraminifer ranges from the beds of San Fernando of Trinidad, referred to the Eocene, to the summit of the Miocene of Jamaica.

The freshwater chert contains species of *Melania*, *Zonites*, *Nematura* or *Amnicola*, *Planorbis*, *Melampus*, *Neritina*, *Truncatella*, *Pomatias?* Of these eight genera, the first three, the 6th and the 8th, are not now represented in Antigua ; and the species of *Planorbis*, *Melampus* and *Truncatella* cannot be identified with those now existing there. The genus *Zonites* is unknown in the Antilles and all Central America; and *Melania* occurs in Cuba but not in the Antilles. A remarkable fact is the faithful reproduction, by the silica, not only of the shells, but in certain cases, of parts of the animal itself, especially in specimens of *Melania*, and, less well, in those of *Zonites*, *Melampus* and *Nematura*.

The shells and corals of the upper limestone and marls have been referred to the Miocene by Prof. Duncan. The fossil corals are to a large extent silicified; and, besides, the beds contain large geodes, made probably through the removal of corals; but the limestone remains unsilicified. The silica is referred to the waters of hot springs.

The recent horizontal marls, which make a terrace along the northeast coast, contain recent terrestrial shells. But two of them, species of *Succinea* and *Helicina*, are not now found in the island. No human remains have been discovered in the beds.

The papers by Prof. Duncan referred to are in the Quart. J. Geol. Soc., xx, 411, 1863, and xxix, 562, 1873, Geol. Mag., i, 97, 101, 1864; by Prof. T. R. Jones, Geol. Mag. i, 102, 1864.

5. *Pennsylvania Geological Survey.*—The following volumes, reports of the progress of the survey, have been recently issued:

No. C[5]. *Field Notes in Delaware County;* by C. E. Hull, with a colored geological map of the county, five engraved colored plates, and thirty-nine photographic views of the Granite Quarries, Kaolin Mines, Serpentine outcrops, and the Castle Rocks. Published in advance of the Geological Report on the County, Part 2, by J. P. Lesley. 128 pp. 8vo. Harrisburg, 1885.

No. RR. *Township Geology of Elk and Forest Counties*, by C. A. Ashburner; *of Cameron County*, by A. W. Sheafer. 404 pp. 8vo, 1885.

No. T[3]. *The Geology of Huntingdon County*, by J. C. White and other assistant geologists; edited by J. P. Lesley. 472 pp. 8vo, with a colored geological map of the county and other folded maps and plates, besides sixty-four page plates, maps and sections.

No. AA. Atlas (colored) of the Eastern Middle Anthracite Field, containing eight folded sheets relating to the portions of the Lehigh basins in the vicinity of Hazleton and Drifton, Luzerne County; C. A. Ashburner, geologist in charge.

The first mentioned of these Reports, on Delaware County, gives an account of the relations of the serpentine and other crystalline rocks of the County to one another and to the Archæan—points that will be fully discussed in Part 2 by Prof. Lesley. Only the general conclusions are here mentioned. Mr. C. E. Hall states that the investigation has demonstrated, through good sections, that the schistose gneisses of the region rest unconformably on the Archæan syenite; that "there are apparently no faults of any consequence within Delaware County to cast a shadow of doubt on the true relations of the schistose rocks to the Laurentian." Further, the Serpentine rocks are in more or less flexed strata, and one in series with part, at least, of the gneisses and other schistose rocks that overlie the Archæan. The author says that "the Serpentine group in this series is the uppermost, or most recent, of the mica schists and gneisses of southeastern Pennsylvania;" and also that "the schists and gneisses, except those of the Syenite group [the Archæan], belong to a more recent formation than the Hudson River age" [top of the Lower Silurian]. A table on page 8 represents these gneisses and schists in three series, the Serpentine as belonging to the upper of the three, and all as probably metamorphosed *Devonian*. The lowest of the three schistose groups contains "coarse mica schists and gneisses, feldspathic and hornblendic gneiss;" and the upper, serpentine. limestone, garnetiferous schist, corrugated ligneous schists and micaceous sandstones, hornblendic gneiss, and feldspathic micaceous gneiss."

The kaolin of the county is in extensive deposits. The particular feldspathic rock from which it is derived is not yet ascertained.

6. *Fossil Scorpion from American Rocks, and other fossils.*—Mr. R. P. Whitfield has a paper, illustrated by two plates, on American Silurian Scorpions, Bulletin No. 6 (vol. i) of the American Museum of Natural History; and the same paper contains reproductions of the figures of the Gothland and Lesmahagow Upper Silurian Scorpions. The American species is from the Waterlime beds at Waterville, N. Y., and is named *Proscorpius Osborni* (*Palæophonus Osborni* of Whitfield in Science for 1885). The specimen was at least one and one-half inches long, and resembles much the living scorpions in general form. Mr. Whitfield observes, in his concluding remarks, that he is inclined to believe the animal to have been aquatic in its habits, and that we have in it a link between the true air-breathing Scorpions and the

Eurypterids. In the Swedish and Scottish specimens the abdomen ends in a stout spine, like modern Scorpions; in the American this portion is absent from mutilation.

The same number of this Bulletin contains descriptions, by Mr. Whitfield, of a new Lituites (*L. Bickmoreanus* Wh.) from the Niagara limestone at Wabash City, Indiana, and of a Homalonotus (*H. major* Wh.) from the upper part of the Oriskany Sandstone of Ulster Co., N. Y. The Homalonotus had a breadth of five and one-half inches, and, judging from the large but imperfect specimen, was probably fifteen and one-half inches long.

7. *Mineral Resources of the United States.* Calendar years 1883 and 1884, by ALBERT WILLIAMS, Jr., Chief of Divison of Mining Statistics and Technology. 1016 pp. 8vo. Washington, 1885. (U. S. Geological Survey, J. W. POWELL, Director).—This report, the second of the series, brings the statistics of the mining industries of the United States down to December 31, 1884. It is a large volume containing a vast amount of valuable information on a wide range of topics. The successive chapters on coal, coke, petroleum, natural gas, the metals, gold, silver, copper, lead, etc., also on building stones, clays, precious stones, phosphates, salt and so on, have been for the most part prepared by specialists, whose united contributions, with the labors of the editor, make a work of more than usual importance.

8. *Contributions to Mineralogy;* by F. A. GENTH.—Dr. Genth has added another to his important papers on Chemical Mineralogy, giving the results of much careful work. The following are some of the more interesting analyses:

Joseite from San José, Brazil: Te 14·67, Se 1·46, S 2·84, Bi 81·23 =100·20.

Galenobismutite from Sweden: (⅚) S 9·75, Se 12·43, Bi 49·88, Pb 27·88, Ag 0·33; specific gravity 7·145. The formula is Pb(S, Se) + $Bi_2(S, Se)_3$ with S : Se=2 : 1.

Argentobismutite (Silberwismuthglanz of Rammelsberg) from Lake City, Colorado: S [16·66], Bi 52·89, Ag 26·39, Pb 4·06=100; the formula is $Ag_2S + Bi_2S_3$ with a little lead probably replacing part of the silver.

Cosalite from the Alaska mine, Colorado: S 16·80, Se *tr.*, As 0·04, Sb 0·51, Bi 44·95, Pb 28·10, Cu 8·00, Ag 1·44, Zn 0·24=100·08. Also from the Gladiator mine: (½) S 17·17, Sb 0·84, Bi 45·09, Pb 24·61, Cu 5·84, Ag 5·75, Zn 0·58=99·88.

Beegerite from the Treasury Vault mine, Park county, Colorado: S [14·59], Bi 19·81, Pb 50·16, Ag 15·40=100.

Tetrahedrite from the Governor Pitkin mine, associated with sylvanite: (½) S 25·97, As 3·22, Sb 25·51, Bi 0·37, Cu 37·68, Ag 0·60, Zn 7·15, Fe 0·64, Mn 0·10=101·24; specific gravity 4·885.

Polybasite from the Terrible Lode, Clear Creek county, Col.; S [16·70], Sb 10·18, As 0·78, Ag 62·70, Cu 9·57, Fe 0·07=100: specific gravity 6·009.

Arsenopyrite from Northern Alabama: S 18·32, As 47·10, Fe 33·84, Cu 0·70=99·96.

Vanadinite from Wanlockhead, Scotland: V_2O_5 18·04, P_2O_5 0·27, As_2O_5 0·34, PbO 78·39, Cl 2·53 = 99·57.

Annabergite from the Gem mine, Silver Cliff, Colorado: As_2O_5 36·64, NiO 32·64, CoO 0·50, CaO 3·51, MgO 3·74, H_2O 23·94 = 100·95.—*Amer. Phil. Soc. Philad.*, Oct. 2, 1885.

9. *Brief notices of some recently described Minerals.*—LÅVENITE is a mineral of chestnut-brown to yellowish color occurring in monoclinic prismatic crystals. The elements are $a : b : c$ (vert.) = 1·0811 : 1 : 0·8133, $\beta = 71° 24\frac{1}{2}'$. Cleavage parallel to the orthopinacoid. Specific gravity 3·51. An analysis by Cleve yielded: SiO_2 33·71, ZrO_2 31·65, Fe_2O_3 (?) 5·64, MnO 5·06, CaO 11·00, Na_2O 11·32, ign. 1·03 = 99·41, which makes it related to catapleiite, eucolite, etc. The locality is a small island, near Stokö, in the Langesundsfjord, Norway.—*W. C. Brogger in the Geol. För. Förh.*, vii, 598.

CAPPELENITE occurs in hexagonal crystals ($c = 0·4301$) of a brown color, a greasy to vitreous luster on fracture surfaces. No distinct cleavage. Specific gravity 4·407. An analysis by Cleve yielded: SiO_2 14·16, B_2O_3 [17·13], Y_2O_3 52·55, $La_2(Di_2)O_3$ 2·97, Ce_2O_3 1·23, ThO_2 0·79, BaO 8·15, CaO 0·61, Na_2O 0·39, K_2O 0·21, H_2O 1·81 = 100. Occurs very sparingly in small vein of augite-syenite on the Lille Arö in the Langesundsfjord, Norway.—*W. C. Brogger in Geol. För. Förh.*, vii, 599.

PINNOITE is a new borate of magnesium from Stassfurt. It occurs with boracite and picromerite (kainite). It is massive, fine-granular to compact though with sometimes a slightly fibrous structure. The color is sulphur- to straw-yellow or pistache-green. The hardness is 3 to 4 and the specific gravity 2·27. The mean of several analyses by Stromeyer yielded: B_2O_3 [42·50], MgO 24·45, H_2O 32·85, Fe 0·15, Cl 0·18, for which the formula $MgB_2O_4 + 3H_2O$ is calculated.—*H. Staute in Ber. d. Chem. Ges.*, xvii, 1584, *in Jahrb. Min.*, 1885, i, 378.

AVALITE is a new chromium mineral from the quartzite of mercury mines of Mt. Avala near Belgrade. The original mineral was a green earthy substance, very impure, but finally for the most part separated by chemical and mechanical means from the admixed minerals. An analysis of the purest material, consisting mostly of emerald-green scales as seen under the microscope, yielded: SiO_2 56·13, Cr_2O_3 14·59, Al_2O_3 14·37, K_2O 3·54, Fe_2O_3 1·10, MgO 0·43, chromite 1·68, water (hygroscop.) 2·39, ignition 5·38 = 99·61.—*Losanitsch*, ibid, 1885, ii, 409.

POLYARSENITE—SARKINITE.—These are described as two new Swedish arsenates of manganese; they may prove, however, to be the same species. The former, *polyarsenite*, is stated by Igelström (Bull. Soc. Min., viii, 370) to occur massive, without cleavage, with the hematostibiite of the same author (Bull. Soc. Min., viii, 143), in veins in calcite imbedded in tephroite. It is yellowish red, transparent. According to Bertrand it is optically biaxial with a negative acute bisectrix. An analysis by Söderbaum is given (I) below. The locality is the Sjö mines in Sweden.

arkinite, as stated by A. Sjögren (Geol. För. Förh., vii, 724), ccurs massive with two cleavages but the crystalline system nknown. The color is light red, and the luster greasy. An ialysis by Lundström gave the results (II) below. The locality Pajsberg, Sweden.

	As_2O_5	Sb_2O_5	P_2O_5	MnO	FeO	CaO	MgO	PbO	H_2O	CO_2	insol.
.	39·04	1·21	—	50·18	tr	2·88	0·75	—	3·15	3·51	— =100·72
.	41·60	—	0·21	51·60	0·13	1·40	0·98	0·25	3·06	0·76	0·38=100·37

Uintahite is an asphalt-like hydrocarbon from the Uintah Its., Utah. It is obtained in masses several inches in diameter, rittle and breaking with a conchoidal fracture. Its hardness is 2 › 2·5, specific gravity 1·065 to 1·075; the color black and lus-·ous. It fuses easily in the flame of a candle, burning with a rilliant flame like sealing-wax and like this giving a clean sharp npression of a seal. It dissolves in heavy petroleum, also in oil f turpentine when warmed; but not by ordinary alcohol nor by ;her when in fragments. It forms with melted wax a hard black iixture, resembling "burnt wax."—*W. P. Blake in The Engi-eering and Mining Journal*, Dec. 26, 1885.

III. Botany and Zoology.

1. *Contributions to the Flora of the Peruvian Andes, with Remarks on the History and Origin of the Andean Flora*; by ohn Ball, F.R.S., M.R.I.A., F.L.S., &c. Extr. *Journal* of the innean Society, Botany, xxii, pp. 1–64. Read November, and ablished in December, 1885.—The personal observations and the ›llections upon which this essay was founded were made in pril, 1882, in an excursion by railway from Lima up to Chicla, hich although only 75 miles in distance, is at the elevation of ?,220 English feet. Much to his surprise, Mr. Ball found that at iis elevation, he had not yet reached the alpine region, which ally begins about 2000 feet higher. This is three or four :ousand feet higher than Grisebach had placed it, on the author-y of Tschudi and Humboldt: yet is only what we should expect, nce the proper alpine vegetation of the Rocky Mountains in t. 40° N., hardly descends below 10,000 feet, and the oscilla-›ns of temperature in the Peruvian Andes are small.

Equally mistaken, Mr. Ball suspects, must be the common view .at the flora of the tropical Andes is scanty in species as com-ıred with high mountain floras in general. He makes some ›mparisons from which he infers that the paucity is apparent .ther than real, and may be attributed mainly to the paucity of ›llections in the Andes, since these vast regions have been visited › very few points and far between.

About a quarter of the Andean phænogams is of Compositæ, hich is double their ratio in N. America, which again is greater ıan that of any other continent. The characteristic and the ıost abundant Andean Compositæ are the *Mutisiaceæ*. Mr. all, referring to Bentham's indication of the complex affinities of

this group, ventures "to believe that under *Mutisiaceæ* are included very many different lines of descent, but that among them there are some minor groups distinguished by very high relative antiquity." And in another connection he opines "that the arguments that have led some distinguished botanists to consider the great family of Compositæ as of comparatively recent origin to appear to me altogether inconclusive. When I consider the vast variety of forms which it includes, the degree in which some large groups are localized in different regions of the earth, while others, such as *Senecio*, have representatives in every zone, I shrink from the conclusion that their origin can be, even in geological language, at all recent. It is, of course, not inconceivable that plants which we class together under the name *Compositæ* may have come into existence by different lines of descent through gradual modification from different ancestral types. But, when we consider the general agreement in the structure and arrangement of the essential organs, I think that the balance of probability inclines decidedly towards the belief in a community of origin of all the various existing forms. Be that as it may, we are, I think, justified in looking to the mountain region of South America as the original home of many large groups, such as the genus *Baccharis*, most of the *Mutisiaceæ*, and many genera of other tribes."

As to these two suggestions, although it is practically convenient, and perhaps necessary, to bring all the Labiatiflorous *Compositæ* under one tribe, as Bentham has done, it seems to us altogether probable that the existing forms are descended from different lines of ancestry. Indeed by such a conception we can more naturally understand their diverse affinities. But as to the great order they belong to, if there is any large group in which the structure suggests community of origin, it is the *Compositæ*. And we suppose that systematic botanists of large experience would entirely agree with Mr. Ball, that the wide differentiation and distribution of this vast order indicated its high antiquity. Our author has assigned some strong reasons for this opinion. The only argument to the contrary, that we know of, is an ideal one, based upon two suppositions; one, that Dicotyledons culminate in the *Compositæ* and in such-like orders; the other that the highest ideal type of plants must be of the latest evolution. But, indeed, the vegetable commonwealth shows no tendency to culminate in any one group or set of groups; and it is a questionable morphology which would promote the capitulum of a thistle or a dandelion to the head of the class.

We remember an interesting lecture, in which, recognizing the dominant part which the northern hemisphere and its boreal lands, with their favorable configuration, have undoubtedly played in floral distribution, it was inferred that the rôle of the southern had always been comparatively insignificant. But a great deal may have happened in the austral regions before this boreal supremacy was established. Mr. Ball

several years ago brought forward his doctrine of the very high antiquity of our actual temperate and alpine floras, of their co-existence in highly elevated regions of low latitudes even in early times. So now, applying his former conclusions to the southern hemisphere, and to "a period remote even in geological language," he notes that "the special generic types of the antarctic flora" "belong without exception to the great groups or natural orders which are now almost universally diffused throughout the world; and the ancestral types from which they originated were probably carried to that region at a remote period, when the physical conditions of the earth's surface were widely different from those now prevailing." "Various considerations tend to the conclusion that the dispersal of the chief cosmopolitan genera of plants may have coincided with the period of the older secondary rocks; and at that period physical agencies far transcending those of our experience prevailed throughout the earth. If the ancestors of the antarctic types of vegetation were then established in a south polar continental area, and were developed from them by gradual modification, I see no difficulty in believing that they may have maintained themselves through successive gradual changes of physical conditions within the same region, and even that some may still survive within the Antartic Circle."

Whether or not one accepts the idea of such high geological antiquity which Mr. Ball claims for what he calls *Cosmopolitan* types, we must wholly agree with him in his use of this name for them, in preference to that of *Scandinavian*. The latter term was used by Hooker before the relation of the present flora of our temperate zone to a former high-northern vegetation was made clear, and before the types in question could "with more reason be referred to North America than to Scandinavia." Mr. Ball's remark that, as to many of them, "the balance of evidence points to an original home in the high mountains of lower latitudes" chimes in with his favorite and original doctrine. And this indeed seems likely to gain ground the more it is considered and applied, as he is applying it, to the explanation of actual distribution.

The interesting problem is to discriminate, as well as may be, the two commingled elements of the northern temperate floras, one of arctic, the other of more endemic mountain origin. An interesting presentation, as concerns Central Europe, is made in Heer's Nival Flora of Switzerland, a posthumous work, published by the *Société Helvetique des Sciences Naturelles*, of which a summary is given in Nature for Dec. 31.

The following idea is extremely suggestive. "In a zoological as well as a botanical sense Brazil is one of the most distinct and separate regions of the earth. It is in large part a granitic region, from which vast masses of superincumbent strata have been denuded, and where the granite itself has undergone a great amount of decay and ablation. We there see the ruins of one of the greatest mountain masses of the earth, where a very ancient flora and fauna were developed, of which portions were able to

migrate to a distance, while others have been modified to adapt themselves to the gradual changes of the environment. Many vegetable groups, which are but slightly represented in the higher region of the Andes, such, for instance, as the *Melastomaceæ*, probably had their origin in the mountains of ancient Brazil."

We are now only beginning to reach some conception of the rôle which the Andes and their prolongation through Mexico have taken in determining the character of no small part of the North American flora. Following up some ideas which were touched upon in this Journal (vol. xxxviii, Nov., 1884, p. 340) and elsewhere, Mr. Ball writes:—

"When we consider that, although subsidence has probably at various times separated the two portions of the continent, the highlands of Mexico and Central America have, in all probability, served during long periods as a bridge over which some portions of the mountain vegetation may have been transferred from North to South, and *vice versa*, we are led to feel surprise rather at the separations now existing than at the presence of many genera and of a few identical species in the flora of the Andes and that of the Rocky Mountains. It is true that I have reckoned as Andean genera and species many that extend northward as far as Mexico; and it may well be that that region, so rich in varied forms of vegetation, is the original home of some that now appear to be more fully developed in the mountain ranges of Western North America. Among the wide-spread American types we must note two natural orders whose original home may with some confidence be placed in the northwestern part of the continent. The *Polemoniaceæ*, of which about 140 species belong to that region, are represented in the Andes by five species of *Gilia*, one of *Collonia*, and by the endemic genus *Cantua*. They have sent to the Old World two or three species of *Phlox* in Northern Asia [we believe only one, and that not far over the border], and a single emigrant which has reached Britain,—the Jacob's Ladder of old-fashioned gardens,—which maintains a struggling existence in several isolated spots in Europe. The other specially American family is that of the *Hydrophyllaceæ*, of which 12 genera are known in N. America, but which is represented in the Andean chain by only four species of *Phacelia*." The *Loasaceæ* illustrate the opposite course of migration.

A list of the plants which Mr. Ball collected in the upper valley of the Rimac in the Peruvian Andes, with various annotations and the characters of some new species, concludes the present interesting contribution to Andean botany. We believe that a second paper upon the subject may be expected. Two or three comments upon individual plants of the list will bring our review to a close.

Erodium cicutarium.—Although Mr. Ball notes the wide diffusion of this old world species in South America, and that it attends the distribution of cattle, he seems at a loss to account for its presence in the Peruvian Andes at the height of 12,500

feet. He supposes that it has not shown the same readiness to establish itself in North America. This is true of the Atlantic but not of the Pacific side. In California and the adjacent districts the *Alfilaria*, as it is popularly called, has taken such full possession that we can hardly convince even the botanists that it is an introduced plant. The authors of the Botany of California speak of it as "more decidedly and widely at home throughout the interior than any other introduced plant, and, according to much testimony, it was as common throughout California early in the present century as now. . . It is a valuable and nutritious forage plant, reputed to impart an excellent flavor to milk and butter." At Santa Barbara and other parts of southern California, it is used for lawns around dwellings, and it seems to be the only resort. It makes a passable substitute for grass so long as the rainy season lasts or irrigation is kept up. It must have been brought in with the earliest cattle, and have found on the Pacific coast a perfectly suitable climate.

Caldasia of Lagasca, Mr. Ball shows us, must be restored as the name of the genus named *Oreomyrrhis* by Endlicher.

Relbunium, upon a general survey of the species, will in our opinion be found quite untenable as a genus.

Phacelia circinata, which extends almost from one end to the other of the American continent, is said to be singularly constant, exhibiting no marked varieties. But we have in North America a remarkable diversity of forms, the extremes of which, by themselves, no botanist would refer to one species, although intermediate forms inextricably combine them. A. G.

2. J. C. LECOYER, *Monographie du Genre Thalictrum*. Gand. 1885, pp. 249, 8vo, tab. i–v.—This monograph makes a large part of the 24th volume of the *Bulletin de la Société Royale de Botanique de Belgique*, in which the larger part was published early in 1885, the remainder in January, 1886. Botanists may be glad to know that it is also issued as a separate volume (for 12 francs); and may join in our regret that the original pagination is not preserved, nor in any way indicated, nor, indeed, do we find any indication in the separate issue that the author's work was published by the Royal Botanical Society of Belgium. This seems hardly fair to the Society; and the new paging without reference to that of the Bulletin gives biblographical trouble; for some will cite from the Bulletin, as they ought, and others from the separate issue.

The monograph is a laborious and faithful piece of work. We have only a small part of the genus in North America, in fact barely a dozen species out of the 79. And we now count *Anemonella* of Spach (*Thalictrum anemonides*), as a distinct genus of a single species. But our few *Thalictra* are encumbered with many difficulties, both in the limitation of the forms and in nomenclature. In respect to them M. Lecoyer's investigations in the herbaria have much helped out our own notes made at various times. He confirms the impression we had formed from an in-

spection of the plant in the Banksian herbarium that *T. rugosum* of Pursh is the old world *T. glaucum*, wrongly attributed to an American origin. And he shows, what we might have made out at first, that the Thalictrum figured and described in Cornuti's book must have been *T. aquilegifolium* of Europe. An inspection of Morison's figure brings the conviction that he copied from Cornuti, with some change to adapt it to the space. So that the name *T. Cornuti* L., founded on these, must subside.

Our tall polygamous species, with clavate filaments and short blunt anthers must therefore take some other name. Lecoyer brings up that of *T. corynellum* DC., Syst., on the ground that the earlier names, *T. polyganum* Muhl. and *T. pubescens* Pursh, were founded on mixed material. This is true as concerns Pursh's *T. pubescens*. But Muhlenberg's name, the earliest of all, is pure, as the specimen he sent to Willdenow shows, and which Lecoyer has seen; and his description in his unpublished *Florula Lancastriensis* is explicit. We call this the earliest published name; for it is in the first edition of his Catalogue (1813) with a character "smooth, polygamous," which, however short, distinguishes it from any other of the Atlantic States.

T. purpurascens L., the remaining species which Linnæus referred to North America, Lecoyer also suppresses; but we think on insufficient grounds, into which this is not the place to enter. We ought sometimes to strain a point rather than abandon a Linnean name. Lecoyer doubts if we can fully distinguish the two species which were referred to *T. purpurascens*, i. e., *T. revolutum* DC., and *T. dasycarpum* Fisher and Meyer. If he could have studied the variations of this species as he has those of *T. minus* of Europe (of which he enumerates over 200 synonyms) he would most probably have combined them. And if he really knew the well-formed fruit of *T. occidentale*, he might not have reduced the species to the eastern *T. dioicum*, although there are some intermediate forms. A. G.

3. *Nomenclature for Fossil Leaves*, etc.—Dr. Nathorst contributes an article on this topic (*Benennung fossiler Dikotylenblätter*) to the current volume of the Botanisches Centralblatt, (nos. 1, 2, 3), containing suggestions which, we suppose, most systematic botanists would agree to and recommend to the phyto-paleologists. The substance of his doctrine is, that scientific names, for fossil as for existing plants, should as nearly and as clearly as possible express our actual knowledge, neither more nor less. For instance, the imprints of leaves which can be certainly or convincingly referred to existing genera, will of course bear the generic name. When the genus is certainly known to occur in the given stratum, by its fruit or in some cases by very characteristic venation of the leaf, all is clear. But as a rule, in formations older than the Pliocene, fossil imprints should not be referred to living genera without such evidence. It would much better represent the facts, in such cases, to employ the name of the probable genus prefixed to *phyllum*: e. g. *Aceriphyllum*, *Magnoli-*

phyllum, etc. This does not exclude such fossils from the genus, while it does indicate the actual uncertainty. Nathorst adds a note to deprecate the opposition which may be raised against the admission of such names when the prefix happens to be Latin, or at least not Greek; but he fortifies his ground with DeCandolle's apposite remark that such hybrids are quite as good as *bureaucracy*, *centimeter*, *decimeter*, and the like. Moreover, when leaf-imprints from widely separated localities apparently belong to the same species, yet with some difference, it is better to have this difference indicated in the nomenclature by making the name ternary; e. g. *Acer trilobatum Japonicum.* Figures of fossil leaves which represent outlines only, without indications of the exact nervation, are nearly useless for classificatory purposes. All leaf-impressions should be carefully figured, photographically or otherwise: but those that are really not determinable should not be named at all. They may be compared and studied as well without names as with them; and while nameless they are not misleading. A. G.

4. WITTROCK, *Erythrææ Exsiccatæ.* Fasc. II, 1885.—This is issued in the same sumptuous style as the first part. We see with gratification that the appeal to American botanists for material begins to find response. In this volume, of 16 sheets, containing species No. 13 to No. 25, the following are N. American. *Erythræa Douglasii* in a typical state, *E. nudicaulis* in the same, *E. calycosa*, var. *Arizonica*, *E. venusta*, and a new one named *E. curvistaminea*, which the author brings near to *E. Douglasii*, and others may identify with that species. For the curvature of the stamens is probably an incident of the dichogamy, in the manner of *Sabbatia*, which all the large-flowered North American species exhibit. Attention is called to this in the Synoptical Flora, vol. 2, part 1, second edition, p. 405. The American contributors to this fasciculus, Messrs. Pringle, Suksdorf, and Orcutt, are mentioned on the title-page. We have still several species and forms which ought to be represented in this authentic illustration of a difficult genus. A. G.

5. F. BUCHENAU, in Engler's Bot. Jahrbücher, vol. vii, 1885, has published a critical synopsis of the European *Juncaceæ*, partly with reference to Nyman's Conspectus, and with full indications of the principal European exsiccatæ. Dr. Buchenau is the acknowledged master of this subject, and his views concern several of our American species as well. A. G.

6. FERDINAND PAX, in the same fasciculus of Engler's Jahrbücher, having already discussed the general structure and morphology of the Maple genus, has now given us the first part of his monograph, comprising four of his fourteen sections, the *Rubra*, *Spicata*, *Palmata*, and *Trifoliata*. We shall probably pass the work in review when it is all published. Meanwhile, *pace Paci*, we have small belief in the two species near *A. rubrum* which he has characterized from old herbarium specimens collected by Kinn, and preserved in the Berlin herbarium. A. G.

7. R. Spruce, *Hepaticæ Amazonicæ et Andinæ.*—This elaborate monograph fills the two parts of the fifteenth volume of the Transactions and Proceedings of the Botanical Society of Edinburgh (1884–5),—nearly 600 pages of letter press, including a full index of genera and species, and 22 neat lithographic plates. All that remains to the completion of Mr. Spruce's indefatigable labors is the promised introduction, relating to "the physical features of the regions explored, and their connection with the vegetation, especially the hepatic vegetation, with critical remarks on certain of the genera and species." The author's illness has prevented the appearance of this in the present volume. We join in the hope that he may be able to present it in a supplement.

A. G.

8. *Synoptical Flora of North America;* by Asa Gray.—A revised edition of the published portions of this work, viz: of the Gamopetalous Dicotyledons complete, is just issued in the form of a single volume, which, with the supplements and new indexes, now fills nearly a thousand pages, imperial octavo. In order to bring this work more generally within the reach of those interested in botany, the price of these two volumes in one is reduced one half, namely to five dollars. It may be procured as before, of Wm. Wesley, Essex St., London; O. Weisel, Leipsic; Ivison, Blakeman, Taylor & Co., New York and Chicago; and also from the Herbarium of Harvard University, Cambridge, Mass., by addressing the Curator. The latter can also supply a few copies of the Supplements and Indexes contained in this new edition for one dollar.

9. *Prodromus Faunæ Mediterraneæ*, Pars II, *Arthropoda*, by J. Victor Carus.—Part II of this valuable Prodromus of all Mediterranean animal species carries the first volume from pages 283 to 526, and ends with the genus Plagusia among Crustacea.

IV. Astronomy.

1. *Comets* (*Fabry*) *and* (*Barnard*); E. Weiss in *Astronomische Nachrichten*, Jan. 25.—The elements and ephemeris of Comet (Fabry) are by Dr. S. Oppenheim and are subject to some uncertainty. Those of comet (Barnard) are by Dr. Hepperger from observations of Dec. 5, 15 and 31, 1885.

Comet (Fabry).

T = April 4·180, Berlin m. t.

$$\left.\begin{array}{rl} \pi = & 183° \; 41' \; 11'' \\ \Omega = & 36 \;\; 12 \;\; 1 \\ i = & 80 \;\; 52 \;\; 49 \end{array}\right\} 1886{\cdot}0$$

$\log q = 9{\cdot}79386$

1886, Berlin m. t.		a	δ	log r.	log D.	Br.
March	2.5	23h. 21·1m.	+29° 42′	0·0169	0·2148	4·8
April	2.5	23 19·9	+39 59	9 8578	0·0377	22·6
	16 5	23 39·6	+46 42	9·8494	9·7989	70·6
May	1.5	3 10·1	+55 47	9·9117	9·2489	666·8
	16.5	8 21·3	+16 31	9·9989	9·4305	192·4
	31.5	9 12·2	−27 49	0·0819	9·8929	15·5

Brightness Dec. 1 = 1.

gh the brightness at the nearest approach may vary greatly the estimates, there is no doubt that during the last of and the first of May this comet will be a brilliant object— by the facts that at that time the comet is circumpolar and light will not interfere.

Comet (Barnard).

T=1886. May 2·7855, Berlin m. t.

$$\left.\begin{aligned} \pi &= 188^\circ\ 13'\ 38'' \\ \Omega &= 68\ \ 25\ \ 57 \\ i &= 83\ \ 50\ \ 24 \end{aligned}\right\} 1886{\cdot}0$$

$\log q = 9{\cdot}676952$

Berlin m. t.	α	δ	log r.	log D.	Br.
rch 1.0	1h. 56·6m.	+21° 5′	0·1505	0·2416	3·6
16.0	1 52·8	+25 29	0·0640	0·2315	5·6
31.0	1 50·3	+30 37	9·9520	0·1998	10·8
ril 15.0	1 45·4	+36 25	9·8072	0·1311	29.0
30.0	1 37·2	+40 22	9·6815	9·9857	101·1
y 15.0	2 11·5	+29 29	9·7498	9·7080	265·0
30.0	4 25·4	−22 50	9·9019	9·5609	259·0
ne 14.0	7 12·4	−48 32	0·0259	9·8182	44·7

Brightness Dec. 5=1.

ding to the above table this comet also will be a conspicu- bject at the same time as the other. We must therefore pate the unusual occurrence of two bright comets appearing e same month, and on May 1st not very far apart. Comet ard) passes its line of nodes May 20, which line the earth s May 29. Comet (Fabry) passes its line of nodes May 8, line the earth passes April 27, but by later elements this crosses the ecliptic April 25. It is therefore not impos- that the comet may be projected on the sun's disc on the or 27th of April.

te by the translator.—Comet (Fabry) on May 1st, about the of its greatest brightness will be high up in the N.W. dur- he evening. Comet (Barnard) will be situated about 30° from it, setting in the N.W. at about 8.30, so that both s will quite probably be visible together to the naked eye the end of twilight. At its greatest brightness comet ard) rises about two hours before the sun. W. B.

V. Miscellaneous Scientific Intelligence.

Isaac Lea Bibliography (being No. 23 of the Bulletin of . S. National Museum, and No. II of Bibliographies of Amer- Naturalists); by N. P. Scudder. Department of the Interior. l 278 pp., 8vo,—This volume contains a biographical sketch . Isaac Lea, which occupies pages i to lx, and a detailed graphy covering the remaining pages. The great extent of ientific publications of Dr. Lea, the large number of new s he has described, and the high value of his work render ibliography one of special importance to American science. ntions all the species of his papers in chronological succes- gives references to plate and figure as well as page, and

states the locality of his specimens; and later the references are grouped for each species alphabetically arranged. The bibliography is thus a complete index. Besides this, paragraphs are cited where questions of distinctive characters or of dates or priority come in. Dr. Lea's contributions to science, though mostly zoölogical and paleontological, also embrace valuable geological and mineralogical papers. The first of his papers appeared in 1818, in the Journal of the Academy of Natural Sciences of Philadelphia, and related to the minerals found near that city. The first paper on Unios was published in 1827; the last on Unios, nearly 50 years later, in 1874; and the last of his publications—mineralogical, like the first, and treating of the Inclusions in Gems, etc., from original microscopical observations, was issued in 1876. This last subject is still a source of work and enjoyment with Dr. Lea who, it is a pleasure to know, although now in his 94th year, is still "blessed with good health, his mental and physical faculties unimpaired."

OBITUARY.

JOHN L. CAMPBELL, Professor of Geology and Chemistry in Washington and Lee University, died at Lexington, Virginia, on the second of February last, in his sixty-fifth year. Professor Campbell's scientific work was chiefly in the department of Geology, and valuable papers by him on Virginian Geology, showing careful field work, are contained in this Journal. His last paper is the Review of the Geological Reports of Professor Wm. B. Rogers, the closing part of which is published in the present number. He entered upon his professorship at Lexington in 1851. He had the affection and respect of his students, and was esteemed by all who knew him for his great excellence of character. He leaves several sons and daughters, and one, Professor Harry Campbell is already an active geologist, and has for some time been associated with his father in his geological work.

Geology, Chemical, Physical and Stratigraphical, by JOSEPH PRESTWICH, M.A., F.R.S., F.G.S. Vol. i. Chemical and Physical. 478 pp., large 8vo, with colored maps and numerous figures. Oxford, 1886. (Clarendon Press.)

The Fishery Industries of the United States, by G. BROWNE GOODE and his associates, U. S. Commission of Fish and Fisheries. Section I, Natural History of Useful Aquatic Animals, with 277 plates, making 1 vol. 4to of text of 896 pp. and 1 vol. of plates.

Contributions to Canadian Palæontology, by J. F. WHITEAVES. Vol. i, 88 pp., with 12 plates on the Invertebrata of the Laramie and Cretaceous of the vicinity of the Bow and Belly Rivers, etc. Montreal, 1885 (Dawson Bros.). Geol. and Nat. Hist. Survey of Canada.

Bulletin of the Chemical Society of Washington, No. 1, Jan. 12, 1884, to Jan. 14, 1886. 28 pp., 8vo.

Bulletin of the Scientific Laboratories of Denison University, Granville, Ohio, edited by C. L. Herrick, Prof. Geol. and Nat. Hist. Vol. i, with 15 plates. December, 1885. Contains a number of valuable geological and palæontological papers.

Observations on the Junction between the Eastern Sandstone and the Keweenaw Series on Keweenaw Point, Lake Superior, by R. D. Irving. Bull. U. S. Geol. Survey, No. 23, 1885.

The Hoosier Naturalist, R. B. Trouslot, Editor, January, 1886, vol. i, No. 6, pp. 73–96, 8vo. Valparaiso, Indiana.

THE

AMERICAN JOURNAL OF SCIENCE.

[THIRD SERIES.]

ART. XXII.—*On Lower Silurian fossils from a limestone of the original Taconic of Emmons*; by JAMES D. DANA.

[Read at the meeting of the American Association at Ann Arbor in August, 1885.]*

THE Lower Silurian fossils hitherto reported from rocks of the Taconic system have come either from localities to the north of the original Taconic area, in the State of Vermont, or from others to the southwest of it, in Dutchess County, New York. The discovery of fossils which I have now to announce was made the present season in a limestone of the original Taconic series of Professor Emmons, his "Sparry limestone," within a mile and a half of the Massachusetts boundary.

That the facts may be fully understood as to what is the *original* and, therefore, *true* Taconic, a brief review of the subject is here introduced; for mistakes are still continually made by writers on the subject.

Professor Emmons, in his first account of the "Taconic System," which makes thirty pages of his Report (in quarto) on the Geology of New York, published in 1842,—mentioned as the constituent rocks, commencing on the west: (1) "Taconic slate," in eastern New York, including the Hoosic slates;† (2)

* Some changes have since been made in order to include the facts from additional observations on the fossils and rocks of the region.

† Of this division of "Taconic slate," his No. 5, in the tabular statement on page 144, Prof. Emmons says, on page 150, "No organic remains have been found in the rocks; it is even destitute of those obscure markings which are called *fucoids*."

the "Sparry limestone" interstratified with the slates west of the Taconic Range and for the most part lying against the west side of the range; (3) The "talcose" or "magnesian" schist (as he called it) constituting the Taconic Range, and Greylock or Saddle Mountain, the high ridge between Williamstown and Adams in the northwestern angle of Massachusetts; (4) the Stockbridge limestone, east of the range of Taconic schist; (5) quartzyte.

He described the prevailing dip of the strata as eastward, as later investigators have done. He made the sparry or western limestone older than the Taconic schists, the limestone dipping under the schists. The belt of sparry or western limestone (sparry is a misleading term and was afterward rejected by him) he described as extending through the New York towns of Hoosic, Petersburg, Berlin, New Lebanon, Canaan and Hillsdale, along the west side of the Taconic Range.

The above-mentioned series of rocks constituted the Taconic System as propounded and described by Prof. Emmons in 1842. He says, on page 136 of this Report:

"The Taconic System, as its name is intended to indicate, lies along both sides of the Taconic Range of mountains, whose direction is nearly north and south, or, for a great distance parallel with the boundary line between the State of New York and those of Connecticut, Massachusetts and Vermont." He remarks that the rocks extend farther north through Vermont into Canada, but gives no details about Vermont or Canada localities, and adds, "It is, however, in Massachusetts, in the County of Berkshire, that we find the most satisfactory exhibition of these rocks."

Prof. Emmons's declaration, in this first detailed account of the system, as to what is the typical Taconic series, must be accepted; and the geological age of these beds—the rocks of the original Taconic System—whatever it may prove to be, must therefore be taken as the age of the Taconic System.

The stratigraphical observations of Prof. Emmons are right. But he took a step of questioned correctness when he concluded in 1842 that the system was intermediate in age between the New York Potsdam sandstone and what he calls the "Primary" system lying to the eastward; or, as stated, in another place (on page 163) that the rock "appears to be equivalent to the Lower Cambrian of Sedgwick." For the criterion of age which he announced, namely: "As a general rule, certain minerals are found in particular rocks" was of unascertained value; and the facts referred to as a basis of his conclusion: that the Taconic quartzyte is interstratified with limestone; that the limestones are peculiar in grain; and others of related character, are doubtful evidence for separating them

om corresponding New York rocks. He says (p. 139), " we nd no fossils in the rocks of which I am speaking, and hence ın derive no aid from that source upon which any reliance ın be placed." He states no case of unconformability with ıe New York rocks. In a later publication he refers to a case f *dislocation*, as he terms it, in the Hoosic region, but not to ny of true unconformability. Dislocation, that is, faulting, it ı well known, proves nothing as to distinction of system; and ıe particular facts at Hoosic referred to are proved to be of ıerely local interest, by the general range of facts in the 'aconic region.

Through the use of his lithological canon,—*his*, for he was he first to announce it—Professor Emmons had identified, by 844,* areas of Taconic rocks in Rensselaer County, New York, Northern Vermont, Canada, Maine, Rhode Island and Michigan; and later, in New Jersey, Virginia, North Carolina and Georgia; and others have used the canon since with equal success, even sometimes at *very* long range.

In saying that such a use of lithological distinctions was unwarranted, I mean to assert that geological investigation with reference to the canon had not advanced so far as to make its application safe, and render it certain that fossils might not yet be discovered to upset the conclusion. I mean to assert, further, that the conclusion *does not* now stand against actual discoveries of Silurian fossils later than Potsdam that have recently been made.

The history of Taconic geology suggests caution with regard o the use of lithological distinctions as evidence of geological ge. It shows how easy it is, under such prompting, to put ssumptions for facts, to say " I know " when one ought to say ' I doubt," and to build up systems that are likely to fall to pieces.

Professor Emmons, after he had found slates in Washington County, New York, *looking like Taconic*, and which he called Taconic, made the discovery in them of trilobites, large trilobites, which Barrande later pronounced to be *Primordial* species. This was evidence to him that these beds were of later age han the typical Taconic, and so he made for them the subdivision of *Newer* Taconic. The discovery was a grand one, and may well give us a high opinion of Prof. Emmons as a geological observer. But the conclusion that the rocks were rocks of his Taconic system had not been proved.

Prof. Emmons, in his American Geology, where he makes his latest exposition of the Taconic subject (covering with it

* Chapter on the Taconic System of his N. Y. Agricultural Report (1846), ssued in advance of the volume under date of 1844.

† "American Geology," by Prof. E. Emmons. 1855, Part II, p. 40.

122 pages of the volume), includes in the *Lower* Taconic, "as developed in Williamstown and Adams;" the quartzyte; the schists of the Greylock ridge and others west; the Stockbridge limestone; and, with these, the western or "sparry" limestone and the associated slates; that is, all the true original Taconic. To the Upper Taconic (p. 49) he refers the black slates and calcareous beds at Easton, Washington Co., N. Y., which, four or five miles north of Bald Mountain, afforded him the Primordial trilobites; similar slates and limestones at St. Albans, with some sandstones. He also includes the slates and limestone of Poughkeepsie and of the region east of there to Sharon, Connecticut—beds which have recently been proved to contain abundantly, in some localities, Hudson River, Trenton and Calciferous fossils (made known from the Poughkeepsie slates first by Mr. Nelson Dale, and from the limestones, by Prof. W. B. Dwight and the author), and which recent discoveries of Prof. W. B. Dwight prove to be also in part of Potsdam age, as a paper of his, prepared for the present meeting of the Association, announces.*

Now the larger part of all that has been written on the Taconic question is about the outside rocks—the "Newer Taconic." Volumes have been devoted to them which have settled nothing. Emmons did not make those Primordial slates Taconic by calling them so, any more than Dr. C. T. Jackson made the Red sandstone of the Lake Superior region Triassic by calling it so, because the red sandstone of the Connecticut Valley had been determined to be Triassic. Should it be substantiated that the original Taconic of Emmons is in part of Calciferous, Trenton and Hudson River age (that is, Lower Silurian), what has been gained from the effort to prove the Primordial slates of Washington County, N. Y., to be not only Taconic in system, but Taconic *newer* than the original Taconic?

We have now unimpeachable evidence—evidence from fossils—that those Primordial Trilobite beds are *not newer* than the typical or original Taconic; that the limestones of the true, original, typical Taconic, on the contrary, are the newer. The Lower Silurian fossils here referred to were found, as has been stated, in the "sparry" or western limestone of the Taconic System—the oldest limestone stratum of the system according to Emmons in 1842. They are from Canaan, New York, the town next south of New Lebanon. The Boston and Albany railroad, as it crosses the State-line in leaving Massachusetts for Albany enters the town of Canaan and its limestone area; and the fossils have been collected from a cut along the railroad, and from ledges of limestone half a mile south of the road and a mile north of it.

* Published at p. 125 of this volume.

The limestone of this belt is mostly a gray, fine-grained crystalline rock, varying to whitish on one side, and to blackish, faintly crystalline, on the other. Short lines and blotches, suggestive of fossils, are common in its grayer portions, but distinct forms I had failed to find. Hope was renewed during the past winter by receiving, from Mr. D. Clark, of Tyringham, a piece of obviously fossiliferous limestone labeled "West Stockbridge." It led to an unsuccessful search in that town in which I was aided by Prof. Dwight of Poughkeepsie. On his return homeward, Prof. Dwight continued his search in Canaan, N. Y., the next town west, and there he had success. This careful investigator found fossils in the limestone at two localities, one at the railroad tunnel, southeast of Canaan Center, and the other, half a mile to the south, in a feebly crystalline blackish variety of the limestone. I was shortly afterward in Canaan for further search and study of the rocks, and also at other times later; and I discovered evidences of fossils also in the limestone in place two miles east of Canaan Center, on the farm of E. S. Hall, but none as distinct as those of the localities first visited by Prof. Dwight.

Prof. Dwight by slicing and polishing has brought to light several determinable species, notwithstanding the metamorphism of the rock. The paper following this contains the results of a careful study of them by himself and Mr. S. W. Ford; and Plate VII, illustrating it, shows at a glance, that this Taconic limestone is not pre-Cambrian or Cambrian. The species include remains of Murchisonias, Pleurotomarias, Crinoids, Fenestellæ, a Trilobite, and probably of Brachiopods; and multitudes of fragments not determinable. From the fossils, these authors are led to refer the limestone, that is, the part of it affording the fossils, probably to the Trenton period.

Two of the localities affording fossils occur in the main belt of the limestone, where it is half a mile to a mile wide, and the third (the locality at the railroad tunnel) in a limestone area on the west side of an isolated belt of schist or slate, which connects with the main belt two miles north, near Queechy; and they are all within two miles of the Massachusetts boundary and a mile or less from the schist of the Taconic range. The distribution of the areas and the positions of the localities will be given on the map of Middle and Northern Berkshire which I shall soon publish in this Journal.

At the railroad tunnel the limestone dips eastward at a small angle (15° to 20°) beneath the slates; and the locality that has afforded the fossils is hardly 200 yards from the overlying slates on the east and south. Both of the localities found by Prof. Dwight are very near this isolated ridge of schist, that of the tunnel limestone on the west of it, and the other ledge

near the east side; and they render probable, if not certain, the overlying position of the schist in this ridge.

But the fossils above mentioned are not those of the specimen of limestone received from Mr. D. Clark. That specimen was given him by Mr. J. W. Smith, of Canaan-4-Corners, and came from the farm of Mr. E. S. Hall above referred to. Unfortunately, all that is now exposed to view is in three loose angular masses, two feet in cubic size and smaller, and not a ledge.

A fourth larger mass was till recently in sight; but it has had its upper part removed to a considerable depth below the suface in clearing the farm of its rocks, and I was informed by Mr. Smith, that in the removal two wagon loads of blocks were carried off, though a large portion was left under the soil. As the farm was under cultivation through the season, I could not have an opening made. An attempt to find the underground mass made since I left the region has proved unsuccessful; so that it will have to remain undiscovered until another season opens. As to the origin of the four masses, all I can say now is that, if transported, they are not probably from any point outside of the valley; for they are angular masses, little worn, and lie all within fifty feet of one another. As the rock is a porous one, it would wear more easily than other portions of the limestone and hence be likely to be covered with soil.

Although the evidence from these specimens is not yet available because of the doubt as to locality, it is of interest to note that they are almost identical in character with the fossiliferous Wappinger valley limestone (part of Emmons's Western Taconic limestone) at Pleasant Valley, a few miles northeast of Poughkeepsie. Like that, it consists largely of nodules of so-called *Chætetes compactus* (now shown by Mr. Dwight to be a *Solenopora*), which give it the aspect of a conglomerate. Along with this fossil, the eye easily detects disks of crinoids, true Chætetes, and in one case a portion of a large Receptaculites, similar to that found with the same limestone at Rochdale near Poughkeepsie. Prof. Dwight has made slices of the rock and says that it contains all of the kinds of fossils occurring in the Pleasant Valley limestone, and others observed by him only at other localities in that region. There is no doubt of its Trenton age.

In former papers I have presented evidence, gathered by myself and earlier observers, proving that the Taconic range and the adjoining limestones on the east and west, constitute, in the main, a great synclinal or compound synclinal. It hence follows that fossils of the western limestone of Canaan indicate the Lower Silurian age of the eastern or Stockbridge limestone.

But, more than this, the eastern and western limestones have surface connection. From New Lebanon the western con- nues northward, and three miles to the north (in Stephen- wn) it stretches on, in a north by east direction, into Massa- husetts, passing in a broad belt through the towns of Hancock nd Williamstown, as my Berkshire map, above alluded to, will now, confirming Professor Hitchcock's map of 1841. Thence extends northward *uninterruptedly* into Vermont (as the Ver- iont geological survey, and my own observations prove), and ecomes the great central marble belt of that State, passing rough Bennington, Dorset, Rutland, and to and beyond Mid- lebury. Thus the same Taconic limestone belt that contains 'renton and Chazy fossils in Rutland, Vermont and towns irther north, as shown by the Vermont Geological Survey, is ow proved to have Lower Silurian fossils west of the Taconic inge at Canaan in eastern New York.

The reading of this paper at the meeting of the American As- ciation was followed by remarks by Prof. James Hall and also y Prof. N. H. Winchell. Prof. Hall observed rightly that the onclusion as regards the Lower Silurian age of the Taconic rocks 'as not new. This fact I have urged in all my papers on the aconic rocks except the present one; and I made it the special oint of the paper preceding this one, presented in 1882 to the eological Society of London, showing that the conclusion I held ad been sustained by every geologist who had investigated the gion and published on it since the Taconic system was first an- ounced—W. B. and H. D. Rogers, W. W. Mather, E. and C. H. Iitchcock, and A. Wing. In my Manual of Geology, the bibli- graphy of the Taconic system is given under the two heads of uthors sustaining its Lower Silurian age, and those not; and mong the former is the name of Prof. Hall.

Unfortunately for the science, Prof. Hall, while one of the fore- iost to contest the conclusions of Prof. Emmons before the As- ciation of Geologists and Naturalists in 1840 to 1845, published othing on the subject; neither were his remarks before the As- ciation published in its brief proceedings. Moreover, no paper iving his later opinion has since appeared. In 1884 (September 3), 40 years after those discussions, I received from him (as a quel to a letter of enquiry as to any publications of his on the ibject) two plates of stratigraphical sections across the Taconic gion, prepared by him 40 to 45 years since, showing plainly areful labor in the field with reference to settling the debated uestion. This most welcome addition to the facts afforded proof onclusive of the synclinal character of portions of the Taconic inge, as I have stated in a notice of them in volume xxviii (1884) f this Journal (p. 311). I had also asked him in my letter his pinion as to the age of the Hoosic Slates (40 miles north of Ca- aan), from which Prof. Emmons and others, in his publications ater than 1842, had reported Graptolites, this point bearing

directly on the age of the accompanying limestones. In his reply, as I report in the notice (on p. 312), he said that he was at "present uncertain as to the precise period of the Hoosic Slates." Prof. C. H. Hitchcock, in 1884, had referred to the fossils as proving the Lower Silurian age of the limestone, and in a letter of the 30th of January last, says: "I do not recall any fossil there except the graptolites."

At the time of the earlier discussions in 1840 to 1844, in which Professors Hall, Rogers, Mather and others, took part, the only Taconic rocks under consideration were, as Prof. Hall remarked in a letter to me of last September, those of the true Taconic range, as defined in the above paper. I had no part in the discussion; in fact, I knew nothing about the Taconic except what I learned from the discussions after 1842, owing to my absence from the country for the four years previous; my first published opinion on the question is in my Manual of Geology (1863) in which Logan's conclusion was adopted.

The report of Prof. Hall's remarks at Ann Arbor implied that he spoke of having known of fossils from Canaan 40 years since.

But, in a letter received soon after, he informed me that he was misunderstood and that he referred to fossils from the limestone of Hoosic. The graptolites of the Hoosic slates are the only fossils of that town mentioned by Prof. Emmons or others in the various controversial writings on the subject; and as no notice of any fossils in the Hoosic limestone had ever been published, I enquired in another letter as to the species, in order to make the argument from the facts more satisfactory, but have not yet received the desired information. It is to be hoped that they will soon be announced, that the evidence as to the age of the Taconic schist may be of the fullest possible character.

ART. XXIII.—*Preliminary Report of* S. W. FORD, *and* W. B. DWIGHT, *upon fossils obtained in* 1885 *from Metamorphic Limestones of the Taconic Series of Emmons at Canaan, N. Y.* —(With Plate VII.)

A. *Explanatory statements with reference to the paleontological investigations at Canaan, N. Y.*, by W. B. DWIGHT.

IT seems proper to preface the Report on the fossils found in 1885 at Canaan, N. Y., by a few explanatory statements which cannot well be included in that paper.

My brief paleontological observations in the above mentioned district have been made by the valued invitation of Prof. J. D. Dana, in connection with his comprehensive study of that portion of the Taconic range. At the locality where fossils were first discovered, about 2400 feet southerly from the railroad tunnel, only the smaller organisms have as yet been detected. These are very difficult to observe, and therefore to collect,

especially when obscured by the dust of a fresh fracture. The difficulty is much increased by the fact that the ledge is in the shade of thick woods.

In this place I have noticed only one general phase of the rock, that of a massive heavy-bedded limestone, which in many parts has been broken into small fragments and re-cemented by a close network of veins. Although this is a discouraging point for collection, on account of the rough, moss-covered character of the crags, in addition to other difficulties already mentioned, yet it has proved as rich in the smaller organisms as the tunnel locality, if not richer.

At the western end of the railroad tunnel, the features are somewhat different. There is more open ground, and the collecting is far easier. In addition to many of the smaller organisms, there are quite a number of large conspicuous fossils. There is also more variety in the texture of the rock than in the first mentioned locality. The narrow fossiliferous belt which crosses the western roof of the tunnel, presents two varieties; for the width of a few feet along the extreme western edge, the rocks are generally light-colored, quite calcareous, schistose, and inclined to produce in weathering, quite smooth, whitish surfaces. These portions contain the larger and more prominent fossils. The strata lying more above and to the east, are darker, and though highly calcareous, yet much interspersed with delicate shaly or arenaceous layers. In these portions, more particularly where the texture is somewhat shaly, there are films crowded with crinoidal fragments, and delicate gasteropods. The lighter-colored strata do not, however, appear to be quite destitute of such fossils as abound in the others, and I find no good reason for supposing that there is any distinction here of stratigraphical value.

Without extensive application of the processes of polishing and making transparent sections of the specimens here collected, it would have been impossible to have arrived at any satisfactory knowledge of the fauna present.

My paleontological observations at these localities have been brief and entirely preliminary. Having visited the place only on three separate days, I have spent, in all, not more than eight or nine hours at these fossiliferous localities. That so large and interesting a collection should have been made in so brief a time shows how numerous must be the remains still preserved in this crystallized rock.

In view of the difficult and fragmentary character of the material, even after I had most thoroughly developed it, it has been a great gratification to me that Mr. S. W. Ford has consented to participate in the final examinations, and in making a joint report.

B. *Joint Report on the Fossils.*

The fossils which form the subject of this joint examination and report were collected by W. B. Dwight on the days of June 12th, June 23d and October 31st, 1885, at the following localities of metamorphic limestone: (1) The western roof of tunnel No. 192 of the Boston and Albany R. R. at Canaan, N. Y.; and (2) a ledge situated about 2400 feet southerly from the above tunnel. Subsequently, a few slabs of fossiliferous rock from the tunnel were sent from Canaan through Professor Dana, which have furnished us considerable additional interesting material. From similar limestone obtained during the same season by Professor Dana, on the farm of E. S. Hall, about two miles northeast of the tunnel, we have also obtained some evidence of organic structure. Although a thorough paleontological study of the region has not yet been made, and our report must therefore be regarded as only preliminary, enough has nevertheless been seen to convince us not only of the Lower Silurian age of the strata, but to enable us to fix, with a considerable degree of probability, their exact horizon.

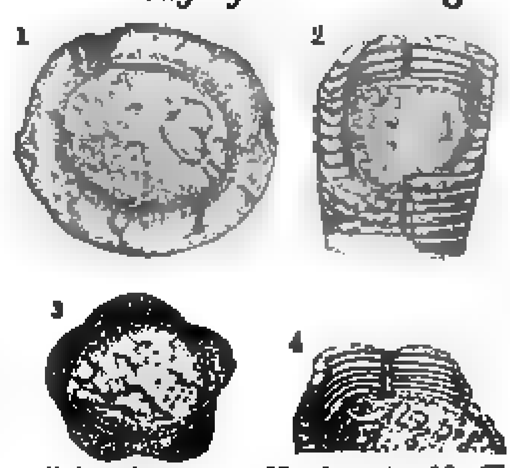
Evidences of the extensive metamorphism of the strata have been constantly met with. The rock, though often abounding in fossils, yet presents them, for the most part, under such conditions as to render their determination a matter of extreme difficulty. The organisms are, to a great extent, in an exceedingly comminuted state, and frequently present the appearance of having been partially dissolved. Many hand specimens of the limestone, and especially transparent sections of it made with much care, appear to strongly indicate the former semifluidal condition of portions of the strata. In other cases, however, where the rock has been less altered, the fossils are quite perfect and sharply defined. The greater portion of the specimens which we have studied, have been brought to light by means of polished surfaces and transparent rock slices, although a number of them are large and conspicuous fossils. In view of the important bearing of the facts with which we have had to deal, we have exercised great care in our examinations and have spared no pains in our endeavors to arrive at safe conclusions.

We have found, in the material under consideration, the following organisms.

ECHINODERMATA.—The majority of the slices and polished surfaces prepared by Professor Dwight from the layers in which the smaller organisms occur, are replete with fragments of small crinoidal columns of forms similar to those so frequently met with in well-known localities of the Trenton limestone. Figures 1 and 2 of Plate VII, of which the first is a transparent

section and the second a polished rock surface, illustrate this fact, and are not exceptional in character. Other slides show these features less perfectly, while in still others their definition is even sharper, as in figs. 3 *a–b*. This latter form we think may represent the column of some known species of *Heterocrinus*. Associated with it there occur the forms shown in figs. 3 *c–f*, which we look upon as joints of encrinal stalks; also the forms represented by figs. 3 *g–j*, which we are disposed to regard as more or less oblique longitudinal sections of the same or similar columns. All of the forms illustrated by figs. *a–j*, have been brought out by means of transparent rock slices, and so strongly resemble, in many respects, certain forms shown in similar slices of limestone of undoubted Trenton age, that we can scarcely doubt the correctness of our interpretations of them. Forms 3 *g–i*, which are quite common, proved extremely puzzling, and have been referred as above only after much laborious comparison.

In the same layers affording the fossils just mentioned, there occur other and larger forms, which appear to us to be likewise crinoidean, with a strong probability that they represent the remarkable species found so abundantly in the Trenton at Newburgh, N. Y., known as *Cleiocrinus magnificus* Billings.* Transverse sections of several of the supposed columns of this species are shown in figs. 4 *e–i* inclusive, and portions of several columns, an inch or more in length, are shown in figs. 4 *a–d*. The absence in these forms, of the minute details of structure so admirably exhibited in the Newburgh specimens, forbids our reaching entirely satisfactory conclusions as to their identity; but the general form of the Canaan specimens, their size, thickness of walls, more or less crystalline, radiating structure, as shown in the transverse section (fig. 4 *e*) so characteristic of crinoidal columns; their surface markings which, upon such weathered specimens as represented by figs. 4 *a*, *b* and *d* seem indicative of close transverse joints, and the evident occurrence of encrinal columns of large size associated with the smaller ones, as in fig. 2, all point toward such identity. Some of the columns



Crinoids from Newburgh, N. Y., natural size.—Nos. 1, 2 and 4, *Cleiocrinus magnificus* (Billings). No. 1, end view of a specimen which is rounded by weathering, and thickened within by incrustation. No. 2 is somewhat compressed in a vertical plane. No. 4 is broken open and very much flattened. No. 3. *Cleiocrinus grandis* (Billings), end view of a very perfect specimen, giving all the characteristic features.

* Geological Survey of Canada, Decade IV, page 54, Plate 5, fig. 3.

of *C. magnificus* collected at Newburgh are flattened so as to present a transverse section precisely like that shown in fig. 4 *i*. For the sake of comparison we have introduced in the text figures illustrative of the columns of *C. magnificus* and *C. grandis* from the Newburgh locality. Fig. 5 represents a portion of the column of another species probably of the same genus, which is chiefly remarkable for the slenderness of its transverse joints. Of these there appear to have been not far from 112 in the space of an inch. The specimen was obtained by grinding down the surface of a small fragment of the Canaan limestone, which abounds in other organisms. It is possible that this fragment may represent a new species of *Cleiocrinus*, and should it turn out to be so, we propose to call it *Cleiocrinus Billingsi*.

Associated with the forms above described there occur several others (figs. 6 *a–g*) all of which may possibly represent portions of large encrinal columns; but as we do not feel satisfied that they are organisms of this nature, and are unable, at the present moment, to refer them with certainty to the Cephalopoda or any other class, we have decided to leave the question of their exact relations an open one. If Cephalopoda, the apparent absence, in all of the examples, of undoubted septa is noteworthy and remarkable. It is barely possible that the oblique lines seen in the interior of fig. 6 *a*, and those crossing 6 *e* may indicate septa, but we cannot feel sure upon this point. In one example (fig. 6 *f*) there are faint indications of the presence of a siphuncle. Some of the specimens, as for example, figs. 6 *c* and 6 *d* suggest a comparison with the opercula of *Maclurea magna*; and we herewith gladly express our obligations to Prof. H. M. Seely, of Middlebury College, Vermont, for his kindness in generously supplying us with beautiful specimens of such opercula for comparison during our investigations.

In the specimen represented by figs. 7 *a*, *b*, there are shown upon one side (fig. 7 *a*) certain more or less definite markings, which very possibly indicate original structure; but we are in doubt as to whether such is really the case. If the markings noticed really represent original structure, they suggest a comparison of the form with specimens of the opercula of *Maclurea magna* now before us. It is quite possible, however, that the specimen is only the column of a *Cleiocrinus*, or rather a portion of one, in which event the markings spoken of might represent the edges of distorted disks.

BRYOZOA.—The only specimen referable to this class that we have recognized among the Canaan fossils, is that shown in figs. 8 *a*, *b*. It was discovered upon the surface of a freshly broken fragment of dark colored, richly fossiliferous limestone, and is very well defined. A careful study of it has led us to

the conclusion that it is most probably a species of *Fenestella* or some closely related generic form; but its specific determination has not been found possible. The specimen is principally interesting as showing that very delicate organic structures have been preserved in a limestone which is, for the most part, so highly metamorphic, that nearly every vestige of fossils has been obliterated; and further, as an indication that, at some favored locality in this limestone, a large and well-preserved suite of decisive specimens will yet be obtained.

BRACHIOPODA.—Fig. 9 appears to us to represent, most probably, the cross section of a brachiopod of about the size and form of the well-known Trenton species *Orthis occidentalis*. It was discovered by polishing a surface of the dark Canaan limestone, and is associated with other organisms. Similar, though less convincing sections, on which we have put the same interpretation, have been observed in other slices which we have studied, and are probably of the same nature. Apart from these examples, however, no forms certainly referable to the Brachiopoda have been obtained from the Canaan limestones, unless some of the structures exhibited in figs. 3 *f*, *i*, represent sections of the ribs of small *Orthidæ*, or allied forms, which may possibly be the case.

GASTEROPODA.—The fossils of this class furnished by the Canaan limestones, afford the most decisive testimony concerning the age of the rocks in question of any that we have examined. They occur in considerable numbers in certain portions of this limestone, associated with comminuted crinoidal remains and other organisms, and are well shown both in transparent rock-sections and upon carefully polished surfaces of ordinary hand-specimens (see fig. 1). We refer the majority of the forms met with to two species, one of which (figs. 10 *a–i*) appears to be, with but little doubt, the *Pleurotomaria subtilistriata* of Hall (Pal. N. Y., vol. i, p. 172, pl. 37, figs. 5 *a–d*); and the other (figs. 11 *a–f*), with even less doubt, the well-known Trenton species *Murchisonia gracilis* (Pal. N. Y., vol. i, p. 181, pl. 39, figs. 4 *a–c*; *ibid*, p. 303, pl. 83, figs. 1 *a–c*). Professor Hall states, in his description of *P. subtilistriata*, that the majority of the specimens are so small as to be scarcely visible to the naked eye; and we have found this true of the Caanan species. This species appears abundantly in sections of the Rochdale Trenton, and slices from the two localities, placed side by side, apart from the apparent absence in the Canaan rock of the common Rochdale coral *Solenopora* (*Chætetes*) *compacta*, are practically undistinguishable.

Associated with the above species there occur the forms shown in figs. 12, 13, 14 and 15, which we look upon as probably representing other species of Gasteropoda, but are unable

to make any sure assignment of them. Fig. 13 is quite possibly a partial transverse section of a shell belonging to the group above referred to *Pleurotomaria subtilistriata* but is not sufficiently definite to enable us to decide this point. Forms 14 and 15 we have simply figured as they appear in polished sections, but prefer for the present, to make no definite disposition of them. They seem to be either distorted forms, or accidental combinations of independent structures.

CRUSTACEA.—The single fragment of the free cheek of a trilobite shown in fig. 16, is the only fossil of this class thus far obtained from the Canaan limestones. We think that it may represent the genal spine of some such species as *Asaphus megistos.*

Fig. 17 apparently represents a coral, which we think, is likely to be the *Chœtetes lycoperdon.* It is a portion of a transparent rock section taken from limestone collected by Professor Dana upon Hall's farm above mentioned. We have been led to suspect the presence of corals, very much altered, among the organisms from the other localities; but have found nothing as definitely outlined as the specimen figured, that can be safely regarded as of this nature. In several of the slices we have also detected what appears to us to be a Stromatoporoid form.

Concluding Remarks.

Judging from the facts above presented, we strongly incline to the opinion that the limestones of Canaan, N. Y., which have afforded the fossils in question, are of Trenton age. We are unable to assert positively that the three Trenton species *Cleiocrinus magnificus*, *Pleurotomaria subtilistriata*, and *Murchisonia gracilis* have been identified among the organisms obtained from these limestones; but we neverthless feel very confident that the forms which we have recognized as probably such, will turn out to be what we have considered them. We consider it safe to affirm that one species, the *Murchisonia gracilis*, has been recognized with so much probability, that its identification may be regarded as established with as much certainty as is possible from a study of sections alone; and we feel almost equally confident in regard to the *Pleurotomaria subtilistriata.* It should be remembered that the more decisive forms brought to our notice, have been presented to us, with but few exceptions, either in polished surfaces or transparent rock-sections; and that the difficulties in the way of correct determination have been, in consequence of this, greatly increased, as compared with determinations undertaken in the usual manner. We present this brief paper hoping that it may serve to throw additional light upon a much debated region, and lead to the development of still more convincing paleontological testimony concerning the precise age of its strata.

EXPLANATION OF PLATE VII.—*Fossils from Canaan, N. Y.*

All the figures are of the natural size except where otherwise described.

Fig. 1.—A transparent section, from the upper dark colored layers at tunnel No. 192; containing abundant fragments of crinoidal stalks, and a number of small gasteropods, probably *Pleurotomaria subtilistriata.*

Fig. 2.—A polished surface of a specimen from the darker layers at the tunnel, filled with sharply defined fragments of small crinoidal columns; containing also several pieces of joints of large crinoids of the *Cleiocrinus* type.

Fig. 3*a*.—A sharply defined vertical section of a crinoid stalk, apparently of the genus *Heterocrinus;* from a transparent slice of a specimen from the tunnel. 3*b*. Same as 3*a*, but twice the natural size. 3*c–g*. Joints of crinoid stalks, all transparent sections; *c* and *d*, are from the locality 2400 feet southerly from the tunnel; the remainder are from the dark layers of the tunnel. 3 *h–j*, doubtful organisms in transparent sections from the tunnel; probably crinoidal fragments (compare with 3*g*), though possibly oblique sections of brachiopod shells. Figs. 3, *e–j*. are twice the natural size.

Figs. 4*a–d*.—Large organisms in relief upon weathered surface of the lower lighter colored layers of limestone at the tunnel. Probably large encrinal stalks of the *Cleiocrinus* type. 4*e–i*. Horizontal sections, probably of large crinoidal stalks of the *Cleiocrinus* type; these appear conspicuously on the surface of the lighter-colored layers at the tunnel. The two separate portions of specimens 4*g* and *f* are on opposite sides of their respective fragments, and are separated by about a quarter of an inch of rock.

Fig. 5.—Portion of a crinoidal stalk, apparently of the genus *Cleiocrinus*, with about 112 joints to the inch; proposed specific name, *Billingsi.* On a polished surface, from upper layers, at the tunnel.

Figs. 6*a–g*.—Various conspicuous, but very doubtful organisms from the lower and lighter layers at the tunnel; presenting features of crinoids, but some also suggesting *Orthocerata.* 6*a*. Shows possible indications of septa. 6*f*. Shows a possible siphuncle; a cross-section of each extremity is given. 6*g*. A cross-section of the smaller extremity, so far as preserved, is given.

Figs. 7*a* and *b*.—The opposite sides of a doubtful organism from the weathered surface of the lower layers at the tunnel. 7*a*. Showing the polished surface of the shell on that side, exhibits what may be lines of structure, about 70 to the inch, variously curved.

Fig. 8*a*.—*Fenestella?* sp.? From dark layers at the tunnel. 8*b*. Same, × 2.

Fig. 9.—Apparently a horizontal section through the hinge of a large brachiopod, like *Orthis occidentalis.* On a polished surface, from the tunnel.

Figs. 10*a–i*.—*Pleurotomaria subtilistriata* probably; *b* and *e* are twice the natural size, and are taken from a transparent slice from the upper layers at the tunnel; *d* is from another transparent section from the locality 2400 feet southerly from the tunnel. *a*, *c*, *f*, *h* and *i*, are all from a polished surface of a single small specimen from the tunnel, upper layers. *g* is from another polished surface.

Figs. 11 *a–f*.—*Murchisonia*, probably *M. gracilis*, *a*, *b* and *d*, are all exhibited on polished surfaces from the tunnel, upper layers, *a* and *d* occurring in the same specimen with the *Pleurotomarias a*, *c*, *f*, *h* and *i*. 11*e* and *f* are the more prominent ones in a confused group of *Murchisonia*, seen in a transparent section from the locality south of the tunnel.

Fig. 12.—Partial vertical and horizontal sections through a single gasteropod (*Pleurotomaria?*) from the tunnel.

Fig. 13.—A partial vertical section passing nearly through the center of a gasteropod, exhibited on the polished surface of the specimen from the tunnel containing the *Pleurotomarias*, *a*, *c*, *f*, *h* and *i*.

Fig. 14.—Probably fragments of one or more gasteropods; polished section from tunnel.

Fig. 15.—Doubtful specimen from the same polished surface as fig. 13.

Fig. 16.—Genal spine of trilobite, perhaps *Asaphus megistos.* From upper layers at tunnel. Exhibited naturally on a freshly fractured surface, being itself nearly black.

Fig. 17.—Apparently a fragment of a coral, perhaps "*Chætetes lycoperdon.*" In a transparent slice of a hand-specimen of limestone collected by Prof. J. D. Dana on Hall's farm, Canaan, N. Y.

ART. XXIV.—*On Surface Transmission of Electrical Discharges*;* by H. S. CARHART.

THE Report of the Commissioner of Patents for 1859, volume "Agriculture," contains an important but little known contribution by Professor Joseph Henry on "Atmospheric Electricity." Under the head of "Electricity in Motion" occurs this passage:—"If the discharge be not very large in proportion to the size of the conductor, it will principally be transmitted at the surface. If the charge be very large, and the conductor small, it will probably pervade the whole capacity, and, as we have seen, will convert into an impalpable powder or vapor the solid particles." Of the latter statement abundant demonstration has recently come under the writer's notice To settle the former point the author of the paper alluded to instituted a series of experiments, only one of which is described. It is fair to infer that this one was deemed the most conclusive. The arrangement in his own words was as follows: "C D is a copper wire . . . . . of the size usually employed for ringing door-bells, passing through the axis of an iron tube, or a piece of gas-pipe, about three feet long. The middle of this wire was surrounded with silk, and coiled into a magnetizing spiral, into which a large sewing needle was inserted. The wire was supported in the middle of the tube by passing it through a cork at each end, covered with tin-foil, so as to form a good metallic connection between the copper and the iron. F and Y are two other magnetizing spirals of iron wire, on opposite sides of the tube, the ends soldered to the iron. When these two spirals were also furnished with needles and a discharge from a Leyden jar sent through the apparatus, as if to pass along the wire, the needle inside of the iron tube was found to exhibit no signs of magnetism, while those on the outside presented strong polarity. This result conclusively shows that, notwithstanding the interior copper wire of this compound conductor was composed of a material which offered less resistance to the passage of the charge than the iron of which the outer portion was formed, yet when it arrived at the tin-foil covering of the cork, it diverged to the surface of the tube, and still further diverged into the iron wire forming the outer spirals."

Several years since I repeated this experiment apparently with the result described above. Doubt was cast on the demonstration, however, by the discovery in one trial that the inner needle was slightly magnetized.

* Read before the American Association for the Advancement of Science, August 27, 1885.

It is evident that the experiment is not conclusive, for the arrangement described constitutes a divided circuit in which one branch, consisting of the gas-pipe, presents much less resistance than the interior copper wire. The greater part of the discharge should accordingly pass along the gas-pipe, and the magnetization of the interior needle would be so slight as to escape detection unless a delicate method of examination were employed.

The matter seemed to be of sufficient importance to justify an experimental inquiry. The investigation has been more extended than was anticipated, because it has met with greater difficulties than were at first apparent; but the results obtained are of considerable interest, and the conclusion of the whole matter settles the main question.

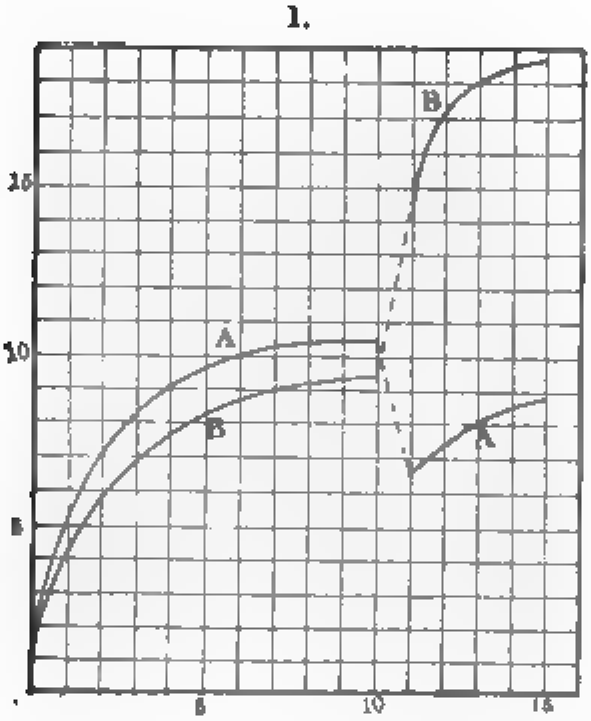
The following arrangement of apparatus was adopted. Two glass tubes about 15^{mm} in diameter were covered with tin-foil for a length of about one meter each. About the tin-foil at each end was secured tightly a copper clamp. Two similar magnetizing spirals were made by winding twenty turns of gutta-percha-covered wire round small glass tubes. One of the spirals served to connect the two tin-foil coatings in series by having its terminals soldered to the copper clamps. The other formed the middle of a circuit extending through the inside of the tubes. The two conductors were then joined at the remote ends of the glass tubes so as to form a divided circuit,—one of the tin-foil and connecting helix, the other of the wire passing through the inside of the tubes and containing the other helix. *The two branches were adjusted to very accurate equality of resistance.* Through this compound circuit a Leyden jar was discharged; and the method finally employed to measure the relative portions of the charge passing through the two branches was to determine the magnetic moment imparted to two similar rods of steel, 1·8^{mm} in diameter and 6^{cm} long, tempered glass-hard, one inserted in each spiral. The Leyden jar of about 700 square centimeters surface was charged by a Holtz machine with fifteen sparks from two to three centimeters in length. The magnet in the inner branch of the divided circuit will be called A; the one in the outer, B.

What Hughes calls "the evident magnetism" of A was in every case greater than that of B after a single discharge of the jar. Upon sending repeated discharges through the circuit, the ratio of the two magnetic moments gradually diminished and the moments themselves approached a maximum, as is shown in fig. 1, where the ordinates denote magnetic moments and the abscissas discharges of the Leyden jar. The moments in arbitrary units are simply fractional parts of the deflection

of the magnetometer, consisting of three pieces of magnetized watch spring attached to the back of a plane mirror. This small magnet was about one centimenter long; and, with the attached mirror, was suspended by a cocoon fiber 10^{cm} long, after the manner described by Gray.* The deflections were read by a telescope and scale at a distance of $1{\cdot}8^{m}$, though this distance varied somewhat in the different sets of experiments, inasmuch as the only quantitative comparisons made were between each pair of magnets used in the magnetizing spirals. The maximum moments were usually attained at ten discharges, the magnetization of the two rods being then pretty nearly equal.

After this nearly stationary condition had been reached, some unexplained facts led to an exchange of the two magnets in the spirals, keeping them turned so that a subsequent discharge would still magnetize them in the same sense as before. A single discharge of the Leyden jar then sufficed to increase the magnetic moment of B from 50 to 60 per cent, and to diminish that of A about half as much, as shown in fig. 1. This was repeated many times with the same invariable result. Continuing the discharges the ordinates of both curves increased as shown. After the magnetization of both rods had approached an apparent maximum, therefore, the mere exchange of the magnets in the spirals was followed by this striking result.

1.



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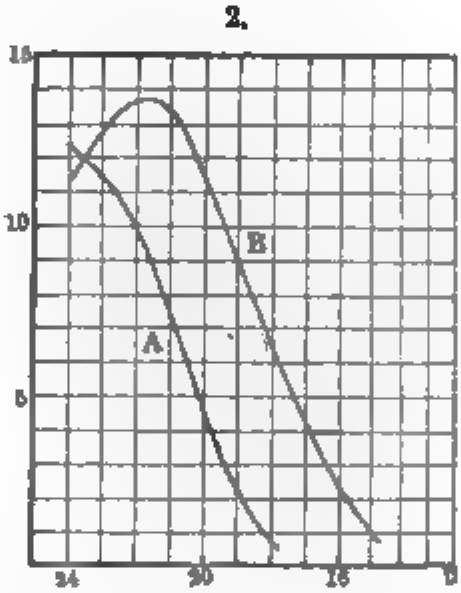

Not finding any information guiding me to an explanation of this curious behavior of the magnets, I sought it by an examination of the physical condition of the magnets themselves after they had reached the maximum of magnetic moment with ten discharges. The outside was gradually eaten away with

* "Absolute Measurements in Electricity and Magnetism," p. 6.

nitric acid, the magnets weighed after each immersion in the acid, and their magnetic moments determined. The results of this process with one pair of magnets are plotted in fig. 2, in which the ordinates are magnetic moments and the abscissas are weights in units of fifty milligrams. The curves therefore represent magnetic moments decreasing with weights. It will be observed that the moment of A decreases from the first continuously, while that of B first rises to a maximum and then falls according to the law exhibited by A. These curves afford a complete explanation of the anomalous deportment of the magnets upon exchanging them in the coils. B has a thin external shell magnetized in a sense opposite to that of the underlying portions. When B takes A's place, this external magnetism is reversed by the first subsequent discharge and made similar to the underlying portions; while A, being placed under B's former conditions, suffers a reversal on the exterior, thus losing in resultant magnetic moment, or "evident magnetism." When the magnets are examined after a single discharge of the Leyden jar they give rise to exactly similar curves, except that the reversed portion of curve B is somewhat longer.

An examination of the conditions under which an oscillatory discharge takes place, and particularly of the formula for the period of an oscillation, will throw light on the reversed curve of B. The first mathematical discussion of electrical oscillations was by Sir William Thomson in 1853,* and was founded on the "equation of energy." Kirchhoff† subsequently arrived at similar equations by introducing into the expression for the electromotive force a coefficient of self-induction. Later writers, Chrystal,‡ Mascart and Joubert,§ have followed the method of Kirchhoff. These investigations show that the discharge will be oscillatory when $R<\sqrt{\frac{4L}{C}}$, in which R is the resistance of the discharger, L the coefficient of self-induction, and C the capacity of the principal conductor. The period of an oscillation is $\frac{\pi}{n}$ where $n=\sqrt{\frac{1}{LC}-\frac{R^2}{4L^2}}$. When R is very small, the period of an oscillation is proportional to $\sqrt{LC}$. In all my experiments the greatest value of R, not including the air resistance of the spark, was 0·58 ohm. We may, therefore, for our purposes consider the period of an oscillation jointly proportional to the square root of the ca-

* Mathematical and Physical Papers, vol. i, p. 540.

† Gesammelte Abhandlungen, "Zur Theorie der Entladung einer Leydener Flasche," p. 168.

‡ Encyclopædia Britannica, vol. viii, p. 81.

§ Electricity and Magnetism, vol. i, p. 512, English edition.

pacity of the principal conductor and of the coefficient of self-induction. This inference, so far as it relates to the capacity of the principal conductor, was confirmed by some experiments of Helmholtz in 1869.*

The bearing of the duration of an oscillation on the reversal of the superficial magnetism is that the mean intensity of the current during the first period is inversely proportional to the length of the period, since the whole quantity of electricity on the principal conductor is discharged during this short interval. Then the magnetic moments, being nearly proportional to the current strength, so long as the saturation point is not approached, will therefore vary inversely as the periods of an oscillation, or inversely as the square root of the coefficients of self-induction, in the two branches of the discharger, even though the quantity discharged through the two branches is the same. The magnetic impulse of both the direct and reverse oscillatory discharge is greater the smaller the coefficient of self-induction in the discharger.

In the experiments thus far described no care was taken to make the coefficient of self-induction in the two branches equal to each other. The inner branch was of copper wire longer than the glass tubes, and coiled into a long helix with the consecutive turns far enough apart to prevent a spark from leaping across. This disposition of the wire increased largely its self-induction. The time of an oscillation through it was therefore greater than in the outer branch, and the magnetic effect of the weaker current less, while the whole quantity discharged through the two branches was the same. Not only then was the mean magnetic moment of B greater than that of A, but the effect of the return discharge was sufficient to produce a reversal of magnetism in B near the surface.

These conclusions are fully confirmed by experiments made with a new arrangement of apparatus, so devised that the coefficients of self-induction in the two branches should be as nearly equal as possible; while at the same time their capacities were made more nearly equal than before, in order to eliminate any possible effect on the period of an oscillation arising from dissimilarity in this respect.

Two† large tubes, 22^{mm} in diameter, were covered with tin-foil for a combined length of 265^{cm}. Two other tubes 15^{mm} in diameter, were also covered for a combined length of 296^{cm}, and the smaller tubes were placed inside the larger ones. One of the magnetizing spirals was made to connect the outer tubes in series, and the other, the inner ones, the other ends of the tin-foil conductors being joined by means of copper clamps and

* Wissenschaftliche Abhandlungen, "Ueber Elektrische Oscillationen," p. 531.

† These experiments were made after the reading of the paper at Ann Arbor.

es of wire, so as to make a divided circuit of two
s before. The cross section of the tin-foil conductor
er tube was made as nearly as possible equal to that
r, so that equality of resistances was secured without
g materially different lengths of wire into the two
The resistances in every case were adjusted to equal-
ns of a sensitive mirror galvanometer and a Kohl-
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is apparatus the magnetic moments of two magnets
eight, cut from the same steel rod and tempered
re almost exactly equal; and the curious phenome-
ted in fig. 1, when the magnets exchanged places in
ls, very nearly disappears. What is perhaps more to
e, the lateral distribution of magnetism in the two
practically identical. Two steel rods as before were
the magnetizing spirals; and after ten discharges of
jar, an examination was made by gradually remov-
er shell with nitric acid and determining the mag-
ent after each removal of about 50^{mgs}. The two re-
rves, shown in fig. 3, are nearly identical. Both
same superficial reversal of magnetic polarity. In
ve B is rotated clock-wise through a small angle
highest point it will coincide with that of A. The
hich this reversed magnetism extends depends, there-
t entirely on the coefficient of self-induction of the
, the principal conductor
capacity being charged
potential. When the
milarity between the two
f a divided conductor is
placed inside the other,
no dissimilarity in the
or distribution of the
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he two branches by a
through the compound
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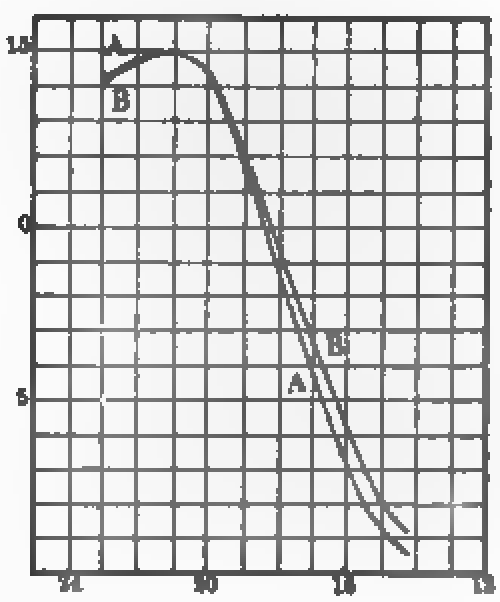
y toward surface trans-
The law of resistance
to dynamic currents
so to electric discharges.
ance is a function of the area of the cross-section
the periphery of the cross-section.
cal bearing of the investigation is that there is no
scientific basis for making lightning conductors of
ce; and that large sectional area in essential to ample
ty.
JII.

3.



ART. XXV.—*The Minerals of Litchfield, Maine;* by F. W. CLARKE.

IN Kennebec County, Maine, along and near the boundary between the towns of Litchfield and West Gardiner, are scattered many bowlders of an elæolite rock. For many years these have yielded to collectors of minerals superb specimens of blue sodalite, yellow cancrinite and zircon; but although the parent ledge appears at several points, it seems nowhere to have been opened. In addition to the minerals already mentioned, the bowlders contain albite, lepidomelane, a black mineral resembling columbite, a flesh-colored mineral which has been called indiscriminately elæolite or cancrinite, and a massive alteration product known to local collectors under the provisional name of "white sodalite." Although specimens from the locality are widely distributed in cabinets, some of the minerals seem to have been but partially described; and I have therefore thought it worth while to study them somewhat closely. The supposed columbite I have not examined, for want of material; the zircon I have omitted, since it has been sufficiently studied by Gibbs;* but the sodalite and cancrinite, although they had been well analyzed by Whitney,† I have included in my investigation, for reasons which will appear below.

ELÆOLITE.

This species occurs abundantly in Litchfield and West Gardiner in characteristic, dark gray, cleavable masses of strong greasy luster. Since it is the typical mineral of its group, and as I can find no published analysis of it from this locality, the following results may have value as a matter of record.

H_2O	·86
SiO_2	43·74
Al_2O_3	34·48
CaO	*trace*
MgO	*trace*
K_2O	4·55
Na_2O	16·62
	100·25

The specimen analyzed contained minute inclusions of black mica, but not enough of them to notably affect its composition. The analysis agrees fairly well with the published analyses of elæolite from other places.

* Poggend. Annalen, lxxi, 559. † Poggend. Annalen, lxx, 431.

Cancrinite.

This mineral is one of the most abundant and characteristic at the locality, and varies considerably in appearance. Two analyses of it were made by Whitney, one of the yellow variety, the other of a greenish modification. I have myself seen nothing to answer to the latter description, but have selected three typical samples for investigation. They may be briefly described and indicated as follows:

A. Bright orange yellow, with strong luster and cleavage, transparent in thin fragments.
B. Dirty pale yellow, less lustrous, highly cleavable, also transparent in thin fragments.
C. Bright yellow, granular. The commonest variety.

For ease of comparison I have tabulated the analyses side by side with Whitney's; indicating his yellow cancrinite by "D," and his greenish variety by "E." The carbonic acid determinations were made for me by Mr. R. B. Riggs, who used the Gooch tubulated crucible, and collected the gas evolved directly in a potash bulb.

	A.	B.	C.	D.	E.
SiO_2	36·29	35·83	37·22	37·42	37·20
Al_2O_3	30·12	29·45	28·32	27·70	27·59
Mn_2O_3	*trace*	*trace*	*trace*	·86	·27
Fe_2O_3	"	"	"		
CaO	4·27	5·12	4·40	3·91	5·26
Na_2O	19·56	19·33	19·43	20·98	20·46
K_2O	·18	·09	·18	·67	·55
MgO	----	----	·07	----	----
H_2O	2·98	3·79	3·86	2·82	3·28
CO_2	6·96	6·50	6·22	5·95	5·92
	100·36	100·11	99·70	100·31	100·53

It will at once be observed that cancrinite "A," which, from its appearance, was presumably the purest type of the mineral, is the highest of all in carbonic acid and lowest in water. It is also the highest in soda and alumina. Whitney's two analyses show more potash than mine, but in other respects run fairly near "C," which, as I have said, represents the commonest, and probably the least pure variety. But in order to understand the variations better, we must consider the flesh-colored mineral referred to in my introductory paragraph, which, as I have said, has been called indiscriminately elæolite or cancrinite, according to the fancy of the collector. It sometimes occurs in specimens of considerable size, is lustrous and cleavable, and to the eye appears perfectly homogeneous. An analysis gave the following results; the carbonic acid, as in the other cases, being determined by Mr. Riggs.

SiO_2	38·93
Al_2O_3	32·52
CaO	2·47
Na_2O	17·02
K_2O	3·23
H_2O	2·83
CO_2	2·95
	99·95

These figures plainly indicate that the mineral is a mixture of elæolite and cancrinite, but do not show whether the mixture is mechanical, or due to isomorphism. To determine this point, Mr. J. S. Diller kindly undertook a microscopic examination of the material, comparing it in thin sections with the elæolite and cancrinite "B," from the specimens of which portions were previously analyzed. He found the mineral to be a merely mechanical commingling of the two species, in nearly equal proportions, and later he succeeded in separating them by means of Sonstadt's solution. This fact, considered together with the apparent homogeneity of the material, renders it probable that the variations in composition of the cancrinite are due to small admixtures of elæolite; and that Whitney's specimens were rather more so contaminated than mine. Still, the entire series of cancrinite analyses are fairly concordant, and confirmatory of each other. In discussing the formula of the mineral, however, analysis "A" will be given preference.

SODALITE.

On account of its beauty, and its intense blue color, this mineral, as it occurs at Litchfield, is a favorite among collectors. It is now somewhat scarce, at least in large or compact specimens, and it ought to be carefully searched for in place. It often occurs intermingled with cancrinite, forming beautifully mottled masses, and also is associated intimately with the white, massive alteration-product to be described later. The following analysis was made, partly for comparison with Whitney's, and partly to aid in the study of the accompanying white mineral.

	Clarke.	Whitney.	Whitney.
SiO_2	37·33	37·30	37·63
Al_2O_3	31·87	32·88	30·93
Fe_2O_3	----		1·08
Na_2O	24·56	23·86	25·48
K_2O	·10	·59	*undet.*
Cl	6·83	6·97	*undet.*
H_2O	1·07	----	----
	101·76	101·60	
Deduct O=Cl	1·54		
	100·22		

In my analysis iron was not looked for, because the ignited alumina, which should have contained it if present, was perfectly white. Otherwise the analyses agree tolerably well.

HYDRONEPHELITE, A NEW SPECIES.

Intimately associated with the sodalite is the white alteration product mentioned in the last paragraph. So close is the association, in fact, and so similar in occurrence are the two minerals, that the latter has been called white sodalite by the local collectors. Like the sodalite it is found in seams, and yields specimens as much as two centimeters in thickness; it is white, lusterless, and has the fracture of sodalite; and probably it originated from the alteration of the latter. Two specimens of it were analyzed, which were received from two different collectors, with the following results:

	A.	B.
H_2O	13·12	13·30
SiO_2	38·90	39·24
Al_2O_3	33·98	33·16
CaO	·05	*trace*
Na_2O	13·21	13·07
K_2O	1·01	·88
Cl	*trace*	----
	100·27	99·65

The alumina carried a trace of iron, and a doubtful trace of manganese was also indicated. Hardness, 4·5. Fusible easily to a white enamel. Soluble in hydrochloric acid, and gelatinizing upon evaporation. Fracture irregular, resembling that of the sodalite. In general, the mineral may be said to have the appearance of a slightly altered feldspar, minus the distinct cleavage.

These analyses left little doubt in my mind that I had a new mineral to deal with, and one belonging to the zeolite family. Such minerals are well-known derivatives of the nephelite group, and thomsonite and natrolite have especially been often noted. In composition the new product differs distinctly from natrolite, but agrees in ratios approximately with thomsonite; forming, as far as chemical evidence alone goes, the soda end of a series passing through rauite, up to ozarkite; the last named mineral being the nearest towards the lime end of the series. A comparison of the analyses of these elæolite derivatives is worth making, on account of its suggestiveness. The ozarkite was analyzed by Smith and Brush, the rauite, from Brevig, by Paykull.*

* Ber. der Deutsch. Chem. Gesell., vii, 1334.

	Ozarkite.	Rauite.	Hydronephelite.
H_2O	13·80	11·71	13·12
SiO_2	36·85	39·21	38·90
Al_2O_3	29·42	31·79	33·98
Fe_2O_3	1·55	·57	----
CaO	13·95	5·07	.05
Na_2O	3·91	11·55	13·21
K_2O	----	----	1·01
	99·48	99·90	100·27

Inasmuch, however, as massive minerals, and especially those which are produced by processes of alteration, are always subject to doubt, I requested Mr. Diller to assist me with a microscopic examination of the new substance. He very kindly acceded to my request, and I subjoin an abstract of his results.

"A section was carefully prepared so as to show both the sodalite and the white, lusterless mineral associated with it, in such a way as to reveal their relations. The extremely irregular line of contact between the sodalite and its secondary products is well defined in transmitted light, but is even more distinct between crossed nicols from the fact that the sodalite, being isotropic, remains dark in all positions, while the other minerals are more or less brilliantly colored. The secondary products, which have clearly resulted from the zeolitization of the sodalite, are two in number. One of them forms very much the larger portion, probably nearly 90 per cent of their total amount, and the other is imbedded in the first in the form of distinct grains. Under the microscope in transmitted light the predominating mineral, which is doubtless a zeolite as shown by your analyses, is more or less deeply clouded like decomposed feldspar. Between crossed nicols it breaks up into flaky grains which vary considerably in the intensity of their color. Some remain dark, others range through light and medium tints of red and yellow, according to the position of the section. The isotropic grains in converging light are proved to be distinctly uniaxial and positive, and the anisotropic ones as far as can be determined exhibit parallel extinction. It is evident therefore that the zeolite must be either quadratic or hexagonal in the system of its crystallization. Some of the grains show an indistinct striation approximately parallel to the vertical axis, but a distinct cleavage could not be discerned. In basal sections three sets of fractures could be rarely made out with sufficient distinctness to suggest that the mineral is probably hexagonal. The mode of its occurrence indicates clearly that it has resulted from the zeolitization of the sodalite; a phenomenon which has been observed in many rocks.

"The small grains of the other secondary mineral are so intermingled with the uniaxial zeolite as to indicate that both are derived from the sodalite. They are easily distinguished from the zeolite in which they are imbedded. In transmitted light they are perfectly clear and transparent, with so high an index of refraction as to appear to rise above the surrounding mass. The grains are entirely without crystallographic boundaries, but are traversed by distinct cleavage lines. Between crossed nicols they are much more brilliantly colored than the associated zeolite, and if the section is rotated they become dark when the cleavage lines make a prominent angle (15°–33°) with the principal sections of the prisms. The mineral is certainly biaxial, and in all probability belongs to one of the two inclined systems of crystallization, but its definite determination is not practicable under the circumstances."

In view of the presence of an impurity in the new zeolite, Mr. Diller suggested a re-analysis of it, to be made on carefully purified material. The purification, by means of Sonstadt's solution, he kindly undertook, determining at the same time the specific gravity of the mineral. The crude material gave him a sp. gr. of 2·263, while the zeolite was a little lighter and the imbedded grains a little heavier. After purification the coarsely powdered zeolite was carefully picked over under the microscope until Mr. Diller felt confident that the sum of all impurities could not exceed one per cent. The mineral, then dried at 100°, gave me the following analytical results:

H_2O	12·98
SiO_2	38·99
Al_2O_3	33·62
CaO	·07
Na_2O	13·07
K_2O	1·12
	99·85

These figures confirm the previous analyses, and show that the impurity which vitiated them must have been small in amount and similar in composition to the new zeolite. The latter, I think, may be considered as fairly well established; and its formula may be written $Al_3(SiO_4)_3Na_2H \cdot 3H_2O$; which requires, water, 13·76; soda, 13·54; alumina, 33·41, and silica, 39·29. This composition, and the manifest relations of the mineral to nephelite, the parent member of the group, naturally suggest for it the name *hydronephelite*, which seems to be both appropriate and descriptive. Chemically, as I have already observed, the species approximates to a soda thomsonite; but optically it appears to be quite different. This fact suggests the desirability of a careful microscopic re-examination of all

the other massive zeolitic alterations of elæolite which have been on analytical grounds referred to the thomsonite series. Hydronephelite, indeed, is directly derived from sodalite, but the latter itself probably originated from elæolite; so that the new species may quite properly be considered along with the other zeolites which were previously mentioned. The fact that it contains more potassium than the sodalite, is noteworthy, and calls for an explanation which I am unfortunately not prepared to offer.

Albite and Lepidomelane.

The albite of Litchfield, which appears to be associated with other undetermined feldspars, is mostly in obscure masses. Occasionally a fragment is found with a translucent cleavage surface one or two centimeters broad. Such a specimen was partially analyzed, giving H_2O 0·52, SiO_2 66·39, Al_2O_3 19·69, K_2O 0·99, Na_2O 10·17. These figures serve only for complete identification of the species.

The lepidomelane exists abundantly in the elæolite rock, but mostly in small black scales. Sometimes tolerably large plates of it are found, black and brilliant, decidedly brittle, and apparently affected by alteration. An analysis gave the following results. The iron determinations were made by Mr. Riggs.

H_2O	4·62
F	none
TiO_2	"
SiO_2	32·09
Al_2O_3	18·52
Fe_2O_3	19·49
FeO	14·10
MnO	1·42
MgO	1·01
K_2O	8·12
Na_2O	1·55
	100·92

This analysis is noteworthy on account of the extremely low percentage of silica, which is approached, so far as I can ascertain, only in an analysis by Rammelsberg of a black mica from Brevig. The ratio between silicon and oxygen is nearly 1:5, which agrees with no known formula. My results make it extremely probable that the mica is a mixture and that it has undergone an alteration tending toward the ultimate development of some chloritic species. Still it deserves, as also do the feldspars of the locality, a more thorough examination.

In attempting to discuss the formulæ of cancrinite, sodalite, and hydronephelite, certain points should be carefully borne in mind. First, the three species must be considered, not independently, but relatively to each other; for all the evidence indicates for them a common origin. That origin is from the first member of the group, elæolite or nephelite; the empirical formula for which has been finally fixed by Rauff.* In partially rational form it may be written $Na_8Al_8(SiO_4)_7(SiO_3)_2$; ignoring the small replacement of sodium by potassium which has been shown by synthetic investigations to be non-essential. Not only does the mode of occurrence and association of the minerals point to community of origin, but the same conclusion is emphasized by the experiments of Lemberg† upon the artificial alteration of silicates. When elæolite from Fredriksvärn was digested 180 hours with a solution of sodium carbonate, a partial transformation into a *soda* cancrinite was effected; while a digestion of six months with a caustic soda solution containing sodium chloride gave a product identical in composition with sodalite. Many such experiments were tried by Lemberg, yielding a large class of similar results. His method of procedure probably did not give absolutely pure or definite compounds, and yet his researches furnish evidence of great value in discussing the chemical structure of many minerals.

If we compare the published analyses of cancrinite from different localites, we shall find that they vary in two ways. First, there are variations which are probably due to small admixtures of elæolite, such as I have shown to occur at Litchfield; and secondly, the ratio between the lime and the carbonic acid ranges between rather wide limits. In the cancrinite from Miask, the two are about equivalent; while the Litchfield mineral contains only half enough calcium to saturate the carbonic acid. The lime and soda, however, vary reciprocally; so that when one is high, the other is low; and, furthermore, the experiment quoted from Lemberg goes to show that a cancrinite may exist containing no lime whatever. If this conclusion be correct, then the carbonic acid of the mineral must be represented as linked with aluminum; a supposition which finds some justification in the existence of the rare species dawsonite. The function of water in cancrinite remains doubtful; if it be regarded as water of crystallization, the formula of the residue becomes less easy to write intelligibly; but if it forms a part of the atomic structure, it is almost necessary to represent the carbonic acid as orthocarbonic, in the group CO_4. This mode of consideration, as will appear later, leads to a

* Zeitschr. für Kryst., ii, 445.
† Zeitschr. der Deutsch. Geol. Ges., xxxv, 557, 1883.

simple general formula for cancrinite, covering all variations in composition except such as are due to impurity, and correlating the mineral with the allied species sodalite and nosean. For the Litchfield mineral the following special formula may be written, giving the theoretical composition in the column below:

$$Al_8(SiO_4)_8(CO_4)_2CaNa_8H_6.$$

	Found.	Calculated.
SiO_2	35·83 to 37·22	35·9
Al_2O_3	28·32 to 30·12	30·6
Na_2O	19·33 to 19·56	18·6
CaO	4·27 to 5·12	4·2
CO_2	6·22 to 6·96	6·6
H_2O	2·98 to 3·86	4·1
		100·0

In this case the water as found is slightly lower, and the soda slightly higher, than the calculated values; which is probably ascribable to the mutual replaceability of sodium and hydrogen.

The formula commonly accepted for sodalite, and the one which is certainly the simplest, is that deduced by Bamberger* from his analysis of the mineral from Tiahuanuco. Written empirically, this formula is $Na_5Al_4(SiO_4)_4Cl$, which requires considerably less chlorine than has ordinarily been found in the species. In Bamberger's analysis, as finally corrected, he obtained 5·54 per cent, as against nearly seven per cent in Whitney's determinations. The difference he ascribes to silica in the chloride of silver as weighed by other analysts; and yet in my own estimation every care was taken to eliminate such impurity, and my results confirm the older figures. Still, both figures have theoretical interest, as will be seen further on; and I am inclined to believe that the Bolivian mineral was more nearly typical than that from Litchfield. To the latter we may assign the empirical formula $Na_9Al_7(SiO_4)_7Cl_2$, which is directly derivable from the formula for nephelite, and which agrees quite sharply with the analyses.

We now have three empirical formulæ ready for comparison side by side, as follows:

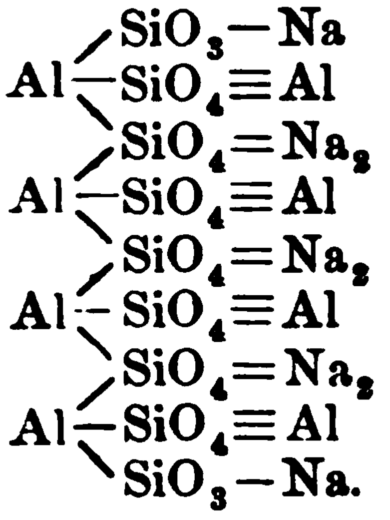
Nephelite	$Al_8(SiO_4)_7(SiO_3)_2Na_8$
Cancrinite (Litchfield)	$Al_8(SiO_4)_8(CO_4)_2Ca\,Na_8H_6$
Sodalite "	$Al_7(SiO_4)_7Cl_2Na_9$

These may easily be put into structural form by an application of the principle suggested in a former paper,† that orthosilicates containing aluminum are to be represented as substi-

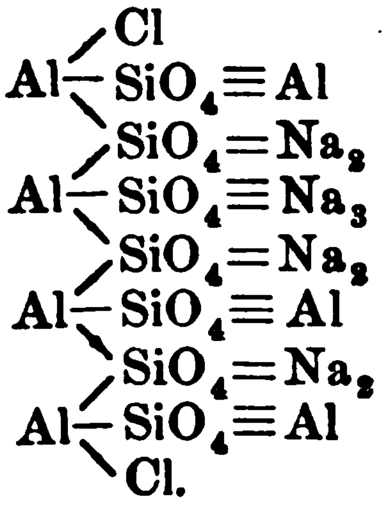
* Zeit. für Kryst., v, 581.

† Clarke and Diller, this Journal for May, 1885.

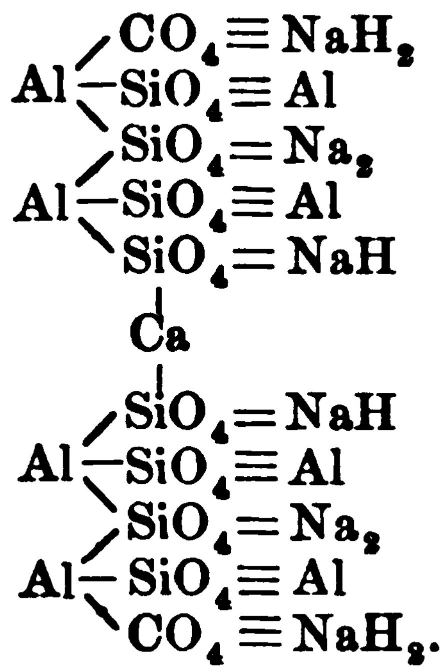
tution derivatives of the normal salt $Al_4(SiO_4)_3$. The latter contains the fundamental nucleus $Al(SiO_4)_3$, which appears to be capable of a sort of polymerization, and which forms the basis of the subjoined symbols.



Nephelite.



Sodalite.

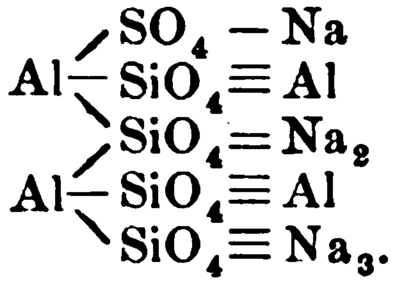


Cancrinite.

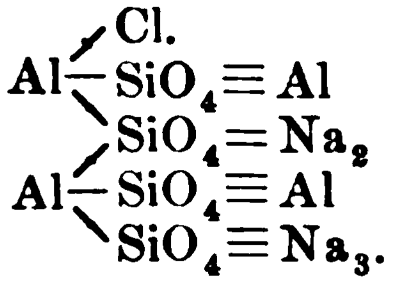
Now although these formulæ fit the analyses, and express a structural similarity of type, two of them are capable of a further generalization. Remembering the reciprocal variations between soda and lime in different cancrinites, and the fact that a soda cancrinite is quite possible, we may write the following general formula for that species; $Al_4(SiO_4)_4CO_4Na_8H_3$; which requires

SiO_2	35·8	
Al_2O_3	30·4	
Na_2O	23·1	Partly replaceable by CaO.
CO_2	6·6	
H_2O	4·1	

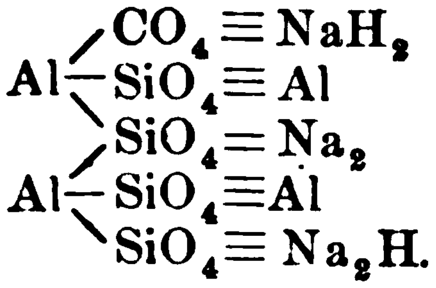
Comparing this with Bamberger's sodalite formula, and with the generally accepted formula for nosean, we have this remarkable series of structural expressions.



Nosean.

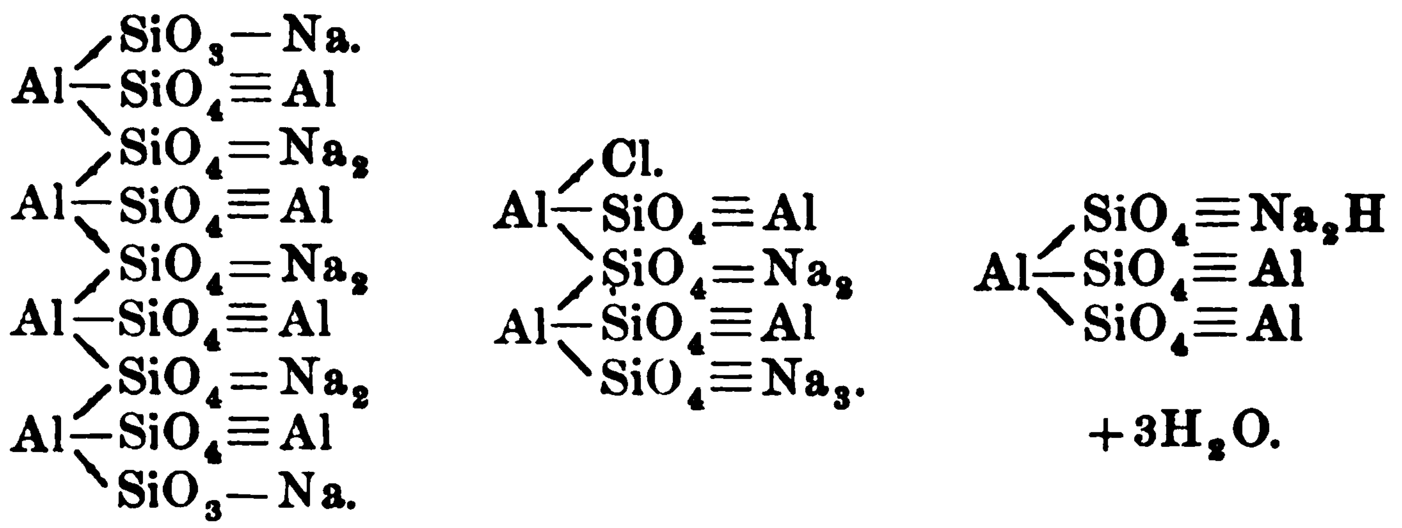


Sodalite.



Cancrinite.

The formula of hauynite of course reduces to the same type, and so also, probably, does that of microsommite. Hydronephelite has a still simpler formula, which, however, includes three molecules of water of crystallization. It may be advantageously compared in series with its parent minerals, in which case we have the following set of structures:



Nephelite. *Sodalite.* *Hydronephelite.*

These formulæ express with decided clearness, the natural order of transition from one species to another. The alteration of a mineral necessarily involves the passage from a less stable to a more stable condition; and in this instance we observe precisely that state of affairs. From a quite complex and therefore easily disturbed molecule, through an intermediate, simpler compound, we pass to one which is simplest of all, and hence, presumably the most stable. I do not deny that such formulæ are subject to criticism, and that possibly the advance of knowledge may brush them to one side; and yet I feel justified in claiming that they have some real value in the coördination of observed facts, and that, through their singular suggestiveness, they assist in the prosecution of research.

Laboratory U. S. Geological Survey, Washington, 1886.

ART. XXVI.—*On the Chemical Behavior of Iron in the Magnetic Field*; by EDWARD L. NICHOLS, PH.D.

[Read at the Ann Arbor meeting of the American Association for the Advancement of Science.]

WHEN finely divided iron is placed in a magnetic field of considerable intensity and exposed to the action of an acid, the chemical reaction differs in several respects from that which occurs under ordinary circumstances. The cause of one such difference may be found in the fact that the solution of iron in the magnetic field is in a sense equivalent to its withdrawal by mechanical means to an infinite distance. Mechanical removal requires the expenditure of work and the same thing is doubtless true of what might be called its chemical removal. In other words the number of units of heat produced by the chemical reaction should differ, within and without the field, by an amount equivalent to the work necessary to withdraw the iron to a position of zero potential. Experiments upon this point which have been briefly described in a note already published

›stract,* brought out other and unlooked-for modifications e reactions.† These have been further investigated and o be described in the present paper. My first experiments, ole object of which was to detect differences in the heat of ıical action within and outside of the magnetic field, were ucted in the following manner. Between the poles of a l electro-magnet, with half inch core, was placed a beaker ıining a known amount of acid. The temperature of the was indicated by a thermometer divided to fifths of a decentigrade. A weighed quantity of powdered iron was ›duced and the rise of temperature was noted at short inter of time until the reaction was complete. The movement ıe thermometer during repeated trials, in which all condi› remained the same, excepting that in alternate experiıs the electro-magnet was active and inactive, served to ʒ out its influence upon the speed and character of the :ion and upon the amount of heat produced.

ıe conditions were varied as to initial temperature, nature strength of the acid used and relative amounts of iron and

In the following detailed account, the various determi›ns are described in the order in which they were made.

I. *Experiments with Aqua-regia and Iron.*

itric and hydrochloric acids were mixed with water in proions which ensured rapid and complete solution of iron out the application of heat. A suitable combination was d by trial to consist of 4 vols. HCl, 3 vols. HNO_3 and 2 H_2O. The acids were the usual concentrated "chemically ›" acids of commerce. 50^{cc} of this mixture were allowed ›t upon two grams of powdered iron of the kind known as n by alcohol."

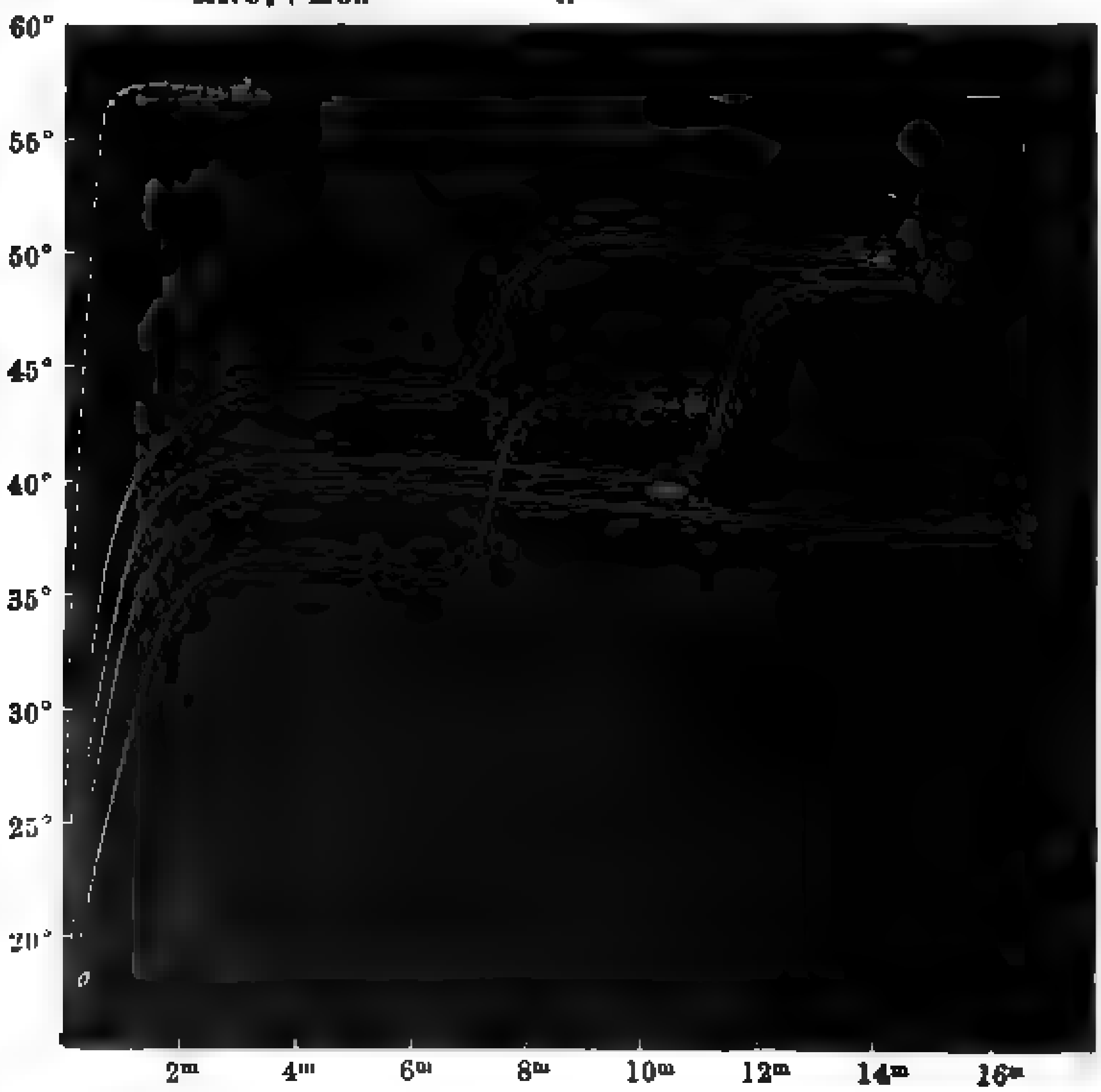
he electro-magnet, already described, was placed, poles upıost, in a glass jar and surrounded with dry sand in order to ent any heating effect from the coils. A beaker holding c. c. was placed directly upon the poles of the magnet. A ɜ bell jar, through the neck of which were set the therıeter and an open glass tube, was placed over the jar conng the magnet in such position that the bulb of the therıeter dipped in the acid within the beaker.

ı. Preliminary Note on the action of Acids on Iron in the Magnetic field: ›edings Am. Association for the Advancement of Science, 1884.

'his appears to be an almost unworked field. Professor Ira Remsen, in his ›sting paper on the "Deposition of Copper on Iron in the Magnetic field" rican Chemical Journal, vol. iii, No. 3, 1881), has furnished the earliest publ evidence of the influence of magnetism upon chemical action. More re› the same author has announced the resumption of his experiments upon ɜubject (Science, vol. i, No. 2, and American Chem. Journal. vol. vi, No. 6,)

The open tube was attached to a water vacuum-pump and after an elapse of five minutes the temperature of the acid was noted. The bell jar was then raised, two grams of iron were thrown into the acid and the bell jar replaced. The vacuum-pump removed all fumes as soon as formed. The temperature of the rapidly effervescing solution was noted at intervals of thirty seconds until the reaction was complete. The violent character of the reaction made all stirring of the solution unnecessary. In order to detect the influence of the magnet a series of these experiments were made in which, as already stated, all other conditions were maintained unaltered and the magnet was alternately active and inactive.

$HNO_3 + HCl$. I.



When iron is dissolved in aqua-regia the character of the reaction varies greatly with the strength and temperature of the acid. At low temperatures and in weak acid, hydrogen is given off and the solution at the completion of the reaction is greenish, containing for the most part ferrous chloride.

At higher temperatures the reaction is more violent, red nitrous fumes are evolved and the resulting solution is yellow

with ferric chloride. Professor Ordway* has described very similar variations in the reaction between nitric acid and iron.

What may be termed the critical temperature, i. e. that at which this change of reaction occurred, was found to be 40°. Reactions in which the solution did not reach that temperature were accompanied by the evolution of hydrogen only, while those in which this temperature was passed were of the double character described by Ordway, the production of hydrogen being followed by that of nitrous fumes. The difference between these reactions is best shown by curves. Curves *a*, *b* and *c*, fig. 1, show the range of temperature during three experiments in which the initial temperature was varied within narrow limits for the purpose of determining the critical temperature. The magnet was not in action during any of these experiments, but in other respects the process was that already mentioned. The curves show the temperature of the solution as a function of the time. Ordinates denote temperature in degrees centigrade, abscissæ time in minutes. The curves "*b*" and "*c*" have two maxima, whereas "*a*" shows no such peculiarity. The portion *o n*, of the curve *o b*, for example, indicates the rise of temperature produced by the solution of the iron under conditions in which hydrogen alone was generated. Whenever the solution reached the critical temperature (40°), a second reaction followed, in which red fumes were given off and a new rise of temperature occurred. The higher the temperature reached during the first reaction the more promptly the second one took place; as may be seen from the diagram. Curves "*b*" and "*c*" show the double reaction, "*a*" represents one in which the critical temperature was not reached and no nitrous fumes appeared.

The first reaction made in the magnetic field, under conditions which would otherwise have ensured the evolution of hydrogen only, was marked by an almost immediate and violent outburst of red fumes accompanied by a correspondingly greater rise of temperature. The reaction was repeated many times and always with the same result. The modification in the reaction produced by magnetic influence may be seen by comparing curve "*d*," which represents the rise of temperature when the reaction took place in the field with curve "*a*." The speed of the reaction is much greater within the magnetic field than without, and the amount of heat produced is greater. The evolution of nitrous fumes and the yellow color of the

* "Malleable iron in dilute nitric acid, sp. gr. 1·03 to 1·06, is attacked with elimination of hydrogen and the production of a ferrous salt or with elimination of nitrous dioxide and the production of a ferric salt or without any evolution of gas." "Sometimes hydrogen is produced at first, then nitrous dioxide, when both ferrous and ferric salts will be formed." Watts' Dict. (Supplement.) See also Ordway, this Journal, II, vol. xl, p. 316.

resulting solution indicated that in the magnetic field the chemical changes were not the same as those produced under other circumstances.

When the above-mentioned reaction was performed below the critical temperature, it was found that the mere actuation of the magnet, at any time before the last particle of iron was dissolved, was sufficient to modify the reaction. The evolution of nitrous fumes always followed the closing of the circuit, in such cases, and the change in the character of the reaction was indicated by renewed rise of temperature. Curve "*e*" shows the range of the thermometer during one of these reactions. The change from the unbroken line to the dotted line shows the point at which the magnet was thrown into action.

Table I gives the observations from which curves *a*, *b*, *c*, *d*, and *e* are drawn. The reactions were repeated many times under the various conditions already described, but the variations from the typical results given in the table were not such as to render necessary the publication of all the observations.

TABLE I.—*Action of aqua-regia upon iron.*

TIME.	Temperature.					TIME.	Temperature.				
	Reaction "*a*" (magnet not acting).	Reaction "*b*" (magnet not acting).	Reaction "*c*" (magnet not acting).	Reaction "*d*" (magnet acting).	Reaction "*e*" (magnet not acting).		Reaction "*a*" (magnet not acting).	Reaction "*b*" (magnet not acting).	Reaction "*c*" (magnet not acting).	Reaction "*d*" (magnet acting).	Reaction "*e*" (magnet not acting).
	°	°	°	°	°		°	°	°	°	°
0m 0s	18·90	20·20	24·70	24·38	19·80	8m 30s	39·30	40·40	50·40	...	43·80
0 30	27·30	28·10	31·10	....	....	9 0	39·20	40·30	50·40	....	43·70
1 0	32·40	33·50	37·80	57·45	34·35	9 30	39·10	40·15	50·30	....	43·00
1 30	35·60	36·80	40·90	57·58	25·70	10 0	39·00	40·00	50·10	....	....
2 0	37·50	38·85	42·50	57·32	36·27	10 30	38·95	39·90*	50·00	....	....
2 30	38·45	39·60	43·20	57·00	36·55	11 0	38·85	40·40	49·80	....	....
3 0	39·10	40·30	43·70	56·75	36·70	11 30	38·75	44·10	....	....	....
3 30	39·45	40·70	43·85	56·37	36·80	12 0	38·62	47·00	....	....	....
4 0	39·57	40·85	44·00	....	36·80	12 30	38·50	47·35	....	....	....
4 30	39·60	40·97	44·05	....	36·80	13 0	38·25	47·50	....	....	....
5 0	39·60	41·00	44·05	....	36·70‡	13 30	38·20	47·37	....	....	....
5 30	39·60	40·97	43·95	....	36·80	14 0	38·10	47·30	....	....	....
6 0	39·60	40·90	43·90	....	36·70	14 30	38·00	47·15	....	....	....
6 30	39·55	40·89	43·60	....	36·57	15 0	37·90	....	....	....	....
7 0	39·50	40·78	43·85†	....	36·45	15 30	37·85	....	....	....	....
7 30	39·45	40·62	49·4	....	42·80	16 0	37·75	....	....	....	....
8 0	39·40	40·50	50·2	....	43·50						

* Red fumes appeared. † Red fumes appeared. ‡ Magnet set into action.

It will be seen that the speed of reaction is greater in the magnetic field than without, and that the heat of chemical union is much greater. The production of nitrous fumes under the influence of the magnet and the yellow color of the resulting solution showed that the reaction was modified in chemical character as well as in intensity.

This form of experiment, however, is ill adapted for comparison of the total amount of heat of chemical union within and without the magnetic field, owing to the very different speeds of reaction. A series of determinations made by my assistant, Mr. W. S. Franklin, in which the reaction took place in a calorimeter, and the number of thermal units produced was measured, showed that the development of heat was always considerably greater within the field of the magnet. The results of this calorimetric series is given in Table II.

TABLE II.—*Calorimetric determination of the heat of chemical union within the magnetic field.* (By W. S. Franklin.)

	Magnet not acting.	Magnet acting.
Mean rise of temperature,	$8^\circ\cdot86$	$11^\circ\cdot03$
Calories per gram of iron dissolved,	1035·0	1288·8

Water value of calorimeter and contents,	583·98 C.
Amount of iron dissolved in each reaction,	5 grams.
Duration of the reaction,	from 5^{mm} to 6^{mm}.

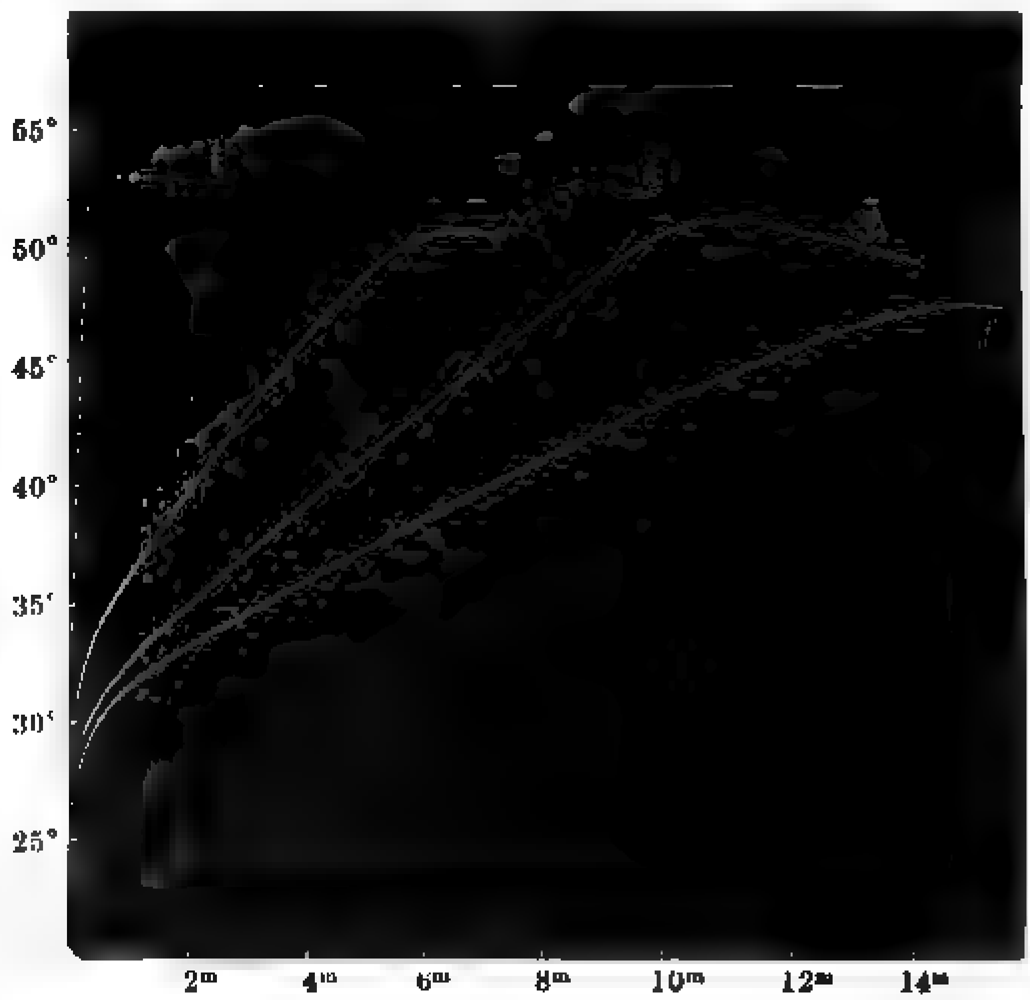
The reaction during these calorimetric determinations was not open to inspection as in the simpler form of experiment in which the variations of temperature alone were noted, but the range of temperatures within the calorimeter was such as to indicate that the reaction within the field was accompanied by the evolution of nitrous fumes, and outside the field by hydrogen only. Whether the amount of heat produced by a reaction in which nitrous fumes were given off outside the field is greater or less than in the corresponding form of reaction under the influence of the magnet was not determined.

II.—*Experiments with Nitric Acid and Iron.*

Nitric acid was mixed in various proportions with water for the purpose of finding the degree of dilution at which the most rapid, uniform and complete solution of the powdered iron could be obtained. During the search for the most desirable mixture, a new and very interesting effect of the magnet was accidentally discovered. Five grams of powdered iron lay in the beaker close above the poles of the electro magnet, which was in circuit. Some cold nitric acid was poured upon the iron but the latter remained passive. Wishing to note the character of the reaction, we warmed the beaker slightly, then placed it upon the poles of the magnet and put a thermometer into the solution to get its temperature. The bulb of the thermometer touched the iron in process of stirring the acid, when the hitherto passive mixture burst, almost explosively, into

effervescence, and a cloud of red nitrous fumes was given off. The removal of the solution from the field of the magnet restored the passivity of the iron, and the action, in a few seconds, ceased entirely. All attempts to destroy the passivity by further stirring failed, until the beaker was brought back into the neighborhood of the magnet, when, at the merest touch with the thermometer, or any glass rod, the reaction would begin again and continue until the beaker was removed from the field. It was found possible to render the iron passive and to destroy that passivity at will by the above process; and after the solution had become warm the reaction was found to begin spontaneously whenever the beaker was brought into the field.

HNO_3 2.



The temperature at which the reaction begins spontaneously in the field was 60°, a point which probably varies with the strength of the acid and the character of the iron.

The further study of this curious phenomenon, which seems to be akin to the influence of the voltaic current upon the passivity of iron, described by Schönn* and by Renard,† was laid aside until a more powerful magnet could be procured.

* L. Schönn: Poggendorff's Annalen, Ergänzungs Bd. v, No. 2.
† A. Renard: Comptes Rendus, t. 79, Nos. 3, 5 and 7.

The proportions selected for the reaction of nitric acid on iron were 70 c.c. HNO_3 and 30 c.c. H_2O acting on two grams of iron. The speed of the reaction without the field was found to vary in a marked manner with the initial temperature. Brisk effervescence of hydrogen occurred, neither accompanied nor followed by the production of nitrous fumes. The effect of the magnet was to greatly increase the speed, reducing the average time from about eight minutes to less than one minute. Red fumes always resulted from the reaction within the field.

To change the character of the ordinary reaction, at any moment, it was only necessary, as in the case of the reaction with aqua-regia, to bring the magnet into function. The production of nitrous fumes, as in the former case was always accompanied by a new rise of temperature, although to a smaller extent than in the aqua-regia reaction.

Table III and curves "f" "g" "h" and "i" figure 2 show the range of temperature during the reactions with nitric acid. The variations of speed caused by slight changes in initial temperature were very marked. A comparison of the total amounts of heat produced within and outside the field cannot be deduced from these curves because of the very different speeds of reaction.

TABLE III.—*Action of nitric acid upon iron.*

TIME.	Temperatures. Magnet not acting. "f"	Magnet not acting. "g"	Magnet not acting. "h"	Magnet acting. "i"	TIME.	Temperatures. Magnet not acting. "f"	Magnet not acting. "g"	Magnet not acting. "h"	Magnet acting. "i"
0m 00s	25°·85	26°·50	27°·25	24°·90	7m 30s	39°·45	44°·95	49°·45*	° ....
0 30	29·65	29·90	34·75	52·50	8 00	40·18	46·10	49·37†	....
1 00	30·50	31·60	35·90	52·80	8 30	40·90	47·00	51·00	....
1 30	31·06	32·55	37·20	52·50	9 00	41·70	48·00	51·18‡	....
2 00	31·92	33·00	38·25	....	9 30	42·58	48·95	50·90	....
2 30	32·55	33·80	39·45	....	10 00	43·35	49·90	....	....
3 00	33·19	35·00	40·70	....	10 30	44·30	50·45	....	....
3 30	33·92	36·10	42·10	....	11 00	45·00	50·75	....	....
4 00	34·58	37·50	44·35	....	11 30	45·65	51·00	....	....
4 30	35·30	38·70	46·72	....	12 00	46·18	50·95	....	....
5 00	36·05	40·10	47·72	....	12 30	46·55	....	....	....
5 30	36·68	40·90	48·45	....	13 00	46·75	....	....	....
6 00	37·38	41·90	48·97	....	13 30	45·95	....	....	....
6 30	38·15	42·90	49·22	....	14 00	46·95	....	....	....
7 00	38·80	43·90	49·40	....					

* First maximum. † Magnet thrown into action. ‡ Second maximum.

III—*Experiments with Hydrochloric Acid and Iron.*

70 c.c. of the concentrated acid diluted with 30 c.c. of water were allowed to act upon two grams of iron. The rise of temperature was much smaller than in the determinations with aqua

regia and nitric acid, the speed of reaction within the magnetic field differed very little from that occurring under ordinary circumstances and the character of the reaction in the two cases was almost identical. The rise of temperature under the influence of the magnet, however, was found to be slightly in excess of that produced when the magnet was not in action. In order to bring out the magnetic influence more clearly than could be done with the magnet described in the first paragraph of this paper a larger one was constructed. The core of the new magnet was 25^{mm} in diameter, and each arm was wound with 840 turns of No. 18 copper wire. This magnet afforded a field many times as strong as that of the small one. With it the reactions of hydrochloric acid upon iron were repeated and all the remaining experiments of the investigation were made.

Considerable difficulty was found in obtaining concordant results with hydrochloric acid, owing to the frequently incomplete solution of the iron. The desired rapidity and completeness of action were however finally secured by using 50 c.c. of the undiluted acid upon two grams of iron at an initial temperature of 40°. Measurements under these conditions and with the larger magnet corroborated the results of the first series, and were free from the irregularities which had vitiated those determinations.

HCl 3. H_2SO_4

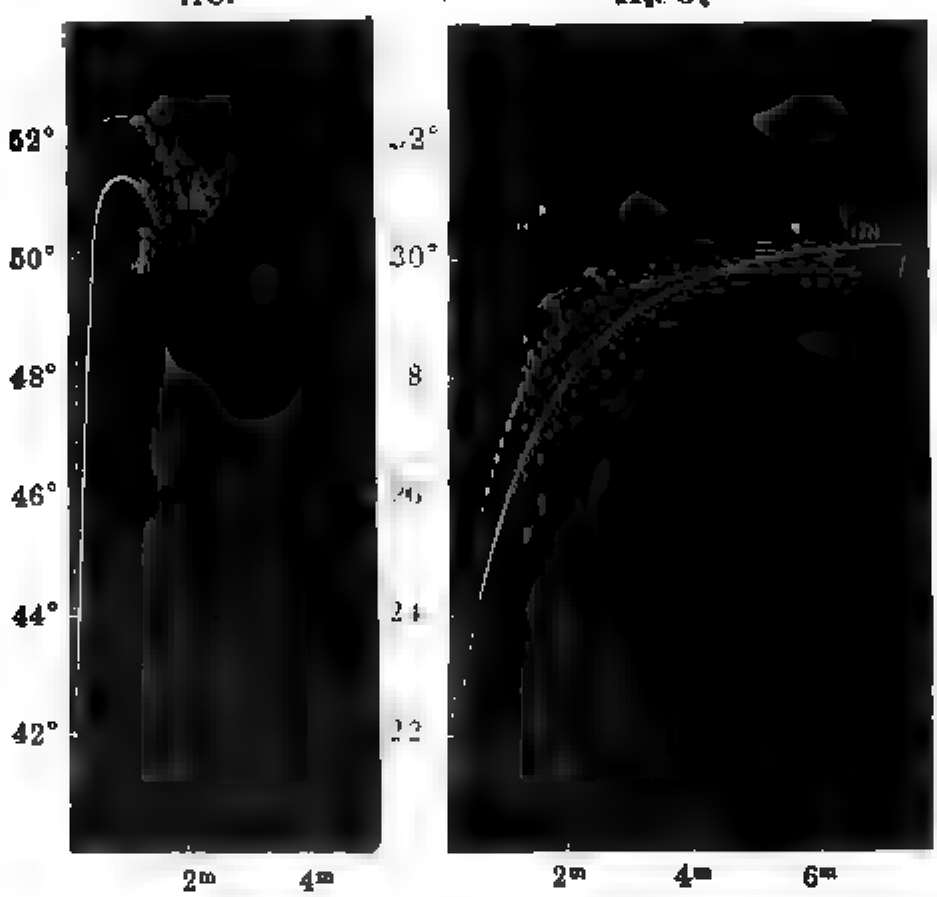


Table IV and curves "j" and "k," figure 3, show the range of temperature during these reactions.

TABLE IV.—*Action of hydrochloric acid upon iron.*

Magnet not acting.		Magnet acting.	
Times.	Temperatures. Reaction "*j.*"*	Times.	Temperatures. Reaction "*k.*"*
0^m 00^s	40°·00	0^m 00^s	40°·00
0 30	50·29	0 30	52·24
1 00	51·39	1 00	52·36
1 30	50·42	1 30	51·98
2 00	----	2 00	----

* Each column gives the mean of ten experiments.

The evidently greater amount of heat produced by the reaction within the field, might be attributed, it was thought, to the formation of a larger percentage of ferric chloride under the influence of the magnet. Volumetric determinations of the amount of ferric salt in the solution, by the hyposulphite of soda method, showed, however, that while the percentage varied between 2 per cent and 14 per cent, it was not larger when the reaction took place within the field than under ordinary circumstances. The rise of temperature was found, moreover, to be independent of the amount of ferric chloride present in the solution and its presence was thought to be due to oxidation after the completion of the reaction.

4. $HCl+KClO_3$

The reaction with hydrochloric acid was afterwards repeated in the presence of an excess of potassium chlorate, by which means all the iron was converted into ferric chlorate. The proportions used were 25^{cc} $HCl+25^{cc}$ $H_2O+1·5$ grams $KClO_3$ acting upon 1 gram Fe. The reaction was rapid and complete, the solution was of a bright yellow color and free from all traces of ferrous chloride. In this case the amount of heat produced in the magnetic field was *much less* than when the magnet

remained inactive, and the speed of the reaction was less. Table V shows the character of these reactions and they are exhibited graphically in curves "p" and "q" (figure 4).

An attempt was made to eliminate the effect of cooling during these reactions by studying the rate of cooling of the solution and correcting the observed rise of temperature by means of data thus obtained. The corrected values are thought to indicate with considerable accuracy the relative amounts of heat produced in the two reactions. They are as follows:

$$\begin{cases} p \text{ (without mag.) ; total rise of temp.} = 33^\circ{\cdot}85 \text{ corr. } 34^\circ{\cdot}46 \\ q \text{ (with '') ; '' '' } = 17^\circ{\cdot}85 \text{ '' } 24^\circ{\cdot}48 \end{cases}$$

TABLE V.—*Solution of hydrochloric acid in presence of potassium chlorate.*

MAGNET NOT ACTING.		MAGNET ACTING.		MAGNET ACTING.	
TIMES.	Temp. Reaction "*p*"	TIMES.	Temp. Reaction "*q*"	TIMES.	Temp. Reaction "*q*"
0m 00s	40°·00	0m 00s	37°·90	3m 00s	55°·00
0 47	73·85*	0 30	45·90	3 30	55·70
....	....	1 00	48·65	4 00	56·70
....	....	1 30	49·95	4 30	57·85
....	....	2 00	52·20	5 00	57·10
....	....	2 30	53·55	5 30	....

* Owing to the great rapidity of the reaction, the only reading taken was at the maximum.

The reaction in which 3 grams of potassium chlorate were used presented no peculiarities such as to necessitate their presentation in tabular form. They were in all respects corroborative of the results given in table V.

IV.—*Experiments with Sulphuric Acid and Iron.*

The method was that already used with other acids.

25cc of the concentrated acid were mixed with 75cc of water, and the mixture when cool was made to dissolve 2 grams of iron. The reaction was uniform and complete and apparently of the same chemical character within and outside of the field. The magnet was found, however, to increase the speed of reaction and to decrease the amount of heat produced. The results are given in table VI, and in curves "m" and "l," figure 3.

TABLE VI.—*Action of sulphuric acid upon iron.*

Magnet not acting.		Magnet acting.	Magnet not acting.		Magnet acting.
Times.	Temp. "m"	Temp. "e"	Times.	Temp. "m"	Temp. "e"
0^m 00^s	21°·50	21°·50	4^m 00^s	30°·12	29°·84
0 30	23·60	24·25	4 30	30·18	29·86
1 00	26·18	27·15	5 00	30·20	29·83
1 30	27·92	28·60	5 30	30·20	....
2 00	28·95	29·61	6 00	30·17	....
2 30	29·45	29·75	6 30	....	....
3 00	29·82	29·80	7 00	....	....
3 30	30·00	29·85			

V.—*Experiments with Nitric Acid and Copper.*

In conclusion of this investigation a series of measurements were made by the methods already described, in which powdered copper, such as is obtained by electrolytic deposition, was substituted for iron. The character of the reaction within and outside of the magnetic field was noted and especial attention was paid to the matter of speed and heat of chemical union. The reaction in the field was found to be identical in both respects with that which occurred when the magnet was not in action. The mean of time determinations showed, for instance, the rise of temperature and duration of action to be:

Within the magnetic field.		*Outside of the magnetic field.*	
Rise of temperature	=4°·875	Rise of temperature	=4°·882
Duration	$=4^m04{\cdot}5^s$	Duration	$=4^m05{\cdot}6^s$

In these experiments 20^{cc} of nitric acid and 30^{cc} of water acted upon 1 gram of copper. Various cursory tests with other metals seemed to indicate that the effects of the magnet described in this paper are confined to reactions in which iron is one of the factors.

The set of experiments described in the preceding paragraphs is to be regarded as preliminary to a more complete investigation of the novel series of effects developed by them. It is my intention to repeat these determinations with a large electromagnet now in process of construction. The further study of the destruction of the passivity of iron by magnetic action is indeed already well advanced and the results will soon be published.

University of Kansas,
Lawrence, Kansas, August, 1885.

ART. XXVII.—*The Inculcation of Scientific Method by Example, with an illustration drawn from the Quaternary Geology of Utah;* by G. K. GILBERT. (With a map, Plate VIII.)

Presidential Address read before the American Society of Naturalists at Boston, December 27, 1885.

Mr. President and Gentlemen:—This is an association of teachers of science and investigators. Those of us who are primarily engaged in investigation have come here more especially as educators. It is our function to discuss, not our results, nor the subject matter of the several sciences with which we are concerned, but our methods of investigation, our methods of publication or promulgation, our methods of teaching.

It is fitting that this, one of the first formal addresses before the Society, should deal with some of the most general considerations affecting methods. In the statement of these considerations it is impossible to avoid that which is familiar, and even much that is trite. Indeed all expectation of entertaining or edifying you with the original or the new may as well be disclaimed at the outset. I shall merely attempt to outline certain familiar principles, the common property of scientific men, with such accentuations of light and shade as belong to my individual point of view.

The teacher's work is susceptible of a logical division into two parts. He stores minds, and he trains them. The modern educator believes the second function to be the higher, because the trained mind can store itself. Nevertheless the two go hand in hand and are in great part inseparable. The effort of the intelligent teacher is to employ such methods in storing the minds of his pupils with knowledge that they shall acquire at the same time the best training.

In that particular department of teaching which is called scientific, there is the same logical duality, and to a great extent there is a practical unity; but in this case there is a pre-determined classification of those who fall under the teacher's instruction, which has the effect of practically dividing his methods. A portion of his pupils are preparing to engage in the work of research, and look to a scientific career. Another portion are to be occupied with business or in other pursuits not implying research, at least in the ordinary sense, and desire to obtain, as a part of a liberal education, an acquaintance with the materials and results of science. The first demand a training in methods, the second consciously ask only for a store of knowledge. Nevertheless, the general student can best accomplish his purpose with the aid of a certain

amount of training in method, while to him who proposes a career of investigation, there is an equal necessity for a large amount of positive knowledge.

Before proceeding to amplify these propositions it seems best to give consideration to the essential nature of scientific research—to restate, for the sake of a common understanding, the process by which science advances.

Scientific research consists of the observation of phenomena and the discovery of their relations. Scientific observation is not sharply distinguished from other observation. It may even be doubted whether there is such a thing as unscientific observation. If there is a valid distinction, it probably rests on the two following characters. Scientific observation, or the observation of the investigator, endeavors to discriminate the phenomena observed from the observer's inference in regard to them, and to record the phenomena pure and simple. I say "endeavors," for in my judgment he does not ordinarily succeed. His failure is primarily due to subjective conditions; perception and inference are so intimately associated that a body of inferences has become incorporated in the constitution of the mind. And the record of an untainted fact is obstructed not only directly by the constitution of the mind, but indirectly through the constitution of language, the creature and imitator of the mind. But while the investigator does not succeed in his effort to obtain pure facts, his effort creates a tendency, and that tendency gives scientific observation and its record a distinctive character.

Scientific observation is moreover selective and concentrated. It does not gather facts indiscriminately, but, recognizing their classification, it seeks new facts that will augment established groups. The investigator, by restricting his observation to a limited number of groups of phenomena, is enabled to concentrate his attention, and thus sharpens his vision for the detection of matters that are unnoticed by the ordinary observer.

The superficial relations of phenomena are discovered by induction—by the grouping of facts in accordance with their conspicuous common characters—or, in other words, by empiric classification. Such empiric classification is a preliminary work in all sciences. It is a convenient and temporary sorting of our knowledge, and with the increase of knowledge it is perpetually remodeled. But it is more than a mere convenience; it is a stepping-stone to a logical, or rational, or, more strictly, relational classification; for it leads to the understanding of those deeper relations which constitute the order of nature.

Phenomena are arranged in chains of necessary sequence. In such a chain each link is the necessary consequent of that

which precedes, and the necessary antecedent of that which follows. The rising of the sun is consequent on the rotation of the earth. It is the logical antecedent of morning light. Morning light is in turn the consequent of sunrise and the antecedent of numerous other phenomena. If we examine any link of the chain, we find that it has more than one antecedent and more than one consequent. The rising of the sun depends on the position of the earth's axis as well as on its rotation, and it causes morning heat as well as morning light. Antecedent and consequent relations are therefore not merely linear, but constitute a plexus; and this plexus pervades nature.

Relational classification may be considered as of two sorts, first linear, and second, coördinate as determined by linear, that is to say, phenomena are linearly arranged in chains of sequence, and they are coördinately arranged in natural classes. A natural class is a group of coördinate facts having the same antecedents.

It is the province of research to discover the antecedents of phenomena. This is done by the aid of hypothesis. A phenomenon having been observed, or a group of phenomena having been established by empiric classification, the investigator invents an hypothesis in explanation. He then devises and applies a test of the validity of the hypothesis. If it does not stand the test he discards it and invents a new one. If it survives the test, he proceeds at once to devise a second test. And he thus continues until he finds an hypothesis that remains unscathed after all the tests his imagination can suggest.

This, however, is not his universal course, for he is not restricted to the employment of one hypothesis at a time. There is indeed an advantage in entertaining several at once, for then it is possible to discover their mutual antagonisms and inconsistencies, and to devise crucial tests,—tests which will necessarily debar some of the hypotheses from further consideration. The process of testing is then a process of elimination, at least until all but one of the hypotheses have been disproved.

In the testing of hypotheses lies the prime difference between the investigator and the theorist. The one seeks diligently for the facts which may overthrow his tentative theory, the other closes his eyes to these and searches only for those which will sustain it.

Evidently, if the investigator is to succeed in the discovery of veritable explanations of phenomena, he must be fertile in the invention of hypotheses and ingenious in the application of tests. The practical questions for the teacher are, whether it is possible by training to improve the guessing faculty, and if so, how it is to be done. To answer these, we must give attention to the nature of the scientific guess considered as a mental

process. Like other mental processes, the framing of hypotheses is usually unconscious, but by attention it can be brought into consciousness and analyzed.

Given a phenomenon, A, whose antecedent we seek. First we ransack the memory for some different phenomenon, B, which has one or more features in common with A, and whose antecedent we know. Then we pass by analogy from the antecedent of B, to the hypothetical antecedent of A, solving the analogic proportion—as B is to A, so is the antecedent of B to the antecedent of A.

Having thus obtained an hypothesis, we proceed to test it. If the hypothetical antecedent is a familiar phenomenon, we compare its known or deduced consequents with A, and observe whether they agree or differ. If it is unfamiliar, we ascertain its consequents by experiment or some other form of observation; and in the selection of the particular experiments or observations to serve as tests, we are guided once more by analogy, inverting the previous formula.

The question, whether or not the function of the mind in devising hypotheses and the tests of them is creative, is foreign to the present purpose. It suffices that we recognize the process as analogic, requiring for its success a preliminary knowledge of numerous instances of consequential relations. The consequential relations of nature are infinite in variety, and he who is acquainted with the largest number has the broadest base for the analogic suggestion of hypotheses. It is true that a store of scientific knowledge cannot take the place of mental strength and training, i. e. of functional ability inherited and acquired, but it is nevertheless a pre-requisite of fertility in hypothesis.

The great investigator is primarily and preëminently the man who is rich in hypotheses. In the plenitude of his wealth he can spare the weaklings without regret; and having many from which to select, his mind maintains a judicial attitude. The man who can produce but one, cherishes and champions that one as his own, and is blind to its faults. With such men, the testing of alternative hypotheses is accomplished only through controversy. Crucial observations are warped by prejudice, and the triumph of the truth is delayed.

Returning now to the subject of education, take first the case in which the student is to become an investigator. He is to observe phenomena, he is to frame and test hypotheses. As a matter of course, in order to learn to do these things he must do them. Sooner or later he must be sent directly to nature, out of doors or in the laboratory, and must in her presence train his faculties by practice. But before he undertakes this, the teacher can aid him by imparting methods. It is probably

not best to offer them in the abstract until he has become well acquainted with them in the concrete. Typical investigations should be described in detail, illustrating the varied phases of the method of hypothesis, and not omitting to show how its successes are achieved through series of failures. The history of at least one science should be developed, with the rise and fall of its successive theories. These educational factors are directed to the training of his mind, but his mind needs also to be stored with scientific knowledge, which shall serve as a foundation for analogies. If he would explain some feature of nature, he must depend on the explanations others have reached for other features; and he needs large resources of knowledge of the relations of phenomena.

The course of training for the apprentice of science should give him, in the study room and in the class room, a varied acquaintance with the laws of nature that have been discovered by research. It should not needlessly burden his memory with empiric classifications, for these belong to the humbler walks of science, and it is unwise to impress on the novice the high importance of that which the master regards as provisional. It should teach observation by actual practice,—practice rigorously restricted to selected groups of phenomena. It should illustrate with varied reiteration—by books, by lectures, by demonstrations in the laboratory—the method of discovery by the aid of hypotheses. It should assign him actual investigation and subject his methods to criticism.

Students whose projected careers are not scientific, but who are unwilling to ignore so important a subject, naturally wish to cover a wide field in a short time. Their teacher, imbued with the vastness of science, is tempted to give them a maximum number of facts, with such order and classification as best favor their rapid statement. If he yields to the temptation, there is reason to fear that a permanent misapprehension is established, and the essence of science is not communicated. In my judgment he will do better to contract the phenomenal, and enlarge the logical scope of his subject, so as to dwell on the philosophy of the science rather than its material. For such students laboratory work may or may not be expedient, but they can at least accompany the pupils who look forward to careers in research in some of the descriptive illustrations of methods of scientific achievement.

The investigator becomes an educator when in giving his work to the world he describes the route by which his end was reached. It is not denied that the publication of sound conclusions is in itself educational, but it is maintained that the publication of the concrete illustration of a good method is educational in a higher sense. It is not insisted that all skillful

investigations should be published *in extenso;* it is only affirmed that the number of such publications is far too small. We need for educational purposes more narratives of good work in all departments of research. Let the discoverer of a new principle recite every hypothesis that occurred to him in the course of his search, telling, if he can, how it was suggested. Let him lay bare the considerations which rendered it plausible, the tests that were conceived, and those which were applied. Let him show in what way the failure of one hypothesis aided in the invention of another. Let him set forth not only the tests which verify his final hypothesis, but the considerations which leave a residuum of doubt as to its validity. And finally let him indicate, if he can, the line or lines of research that promise to throw more light.

By so doing he will accomplish many things. He will guard himself against an overestimate of the strength of his uneliminated hypothesis, and he will thus diminish his self-conceit. By conscious attention to his methods he will improve them. He will therefore educate himself.

He will inspire the young investigator by his example, and even his experienced compeer will take courage from the success that after many failures finally crowns his efforts. He will give to every investigator who reads his paper a lesson in method—a good lesson if his method is good, and not necessarily a bad one if his method is bad. He will therefore educate his fellow workers.

If his work admit of popular presentation, he may be a missionary as well as a teacher, for he may help to dissipate the wide-spread impression that there is something occult in the ways of science. He will at least aid in showing that, whenever a theory is created and tested, knowledge is the gainer, whether the theory itself stands or falls; and that the demolition of hypotheses, instead of testifying to the futility of research, is the method and condition of progress. His educational influence will thus extend to that great lay member, the general reader.

In making this plea for education by example, it would be unfair to ignore another point of view. Not all are willing to be educated, not all need be; the majority of those who examine an essay seek only to learn its conclusions and have time for nothing more. For their use there should be appended or prefaced a concise summary of results.

And, on the other hand, it should be observed that the service rendered to science by one who describes his course of investigation is not educational merely. Rejected hypotheses have a positive value in the domain of the subject to which they belong, and he who makes them public gives to his

fellow-workers in the special field the fullest advantage of his material. Some steps of his progress, which did not prove suggestive to him, will find fertile ground in the mind of another and bear fruit. This consideration places the progress of knowledge before the glory of the individual, and is opposed by a natural egoism; but it is only the man of small calibre who has no ideas to spare, and secretiveness in matters of science is ordinarily a confession of weakness.

It was intimated a moment ago that precept unsupported by example could not be depended on to infuse method—and the dictum applies even to the burden of this discourse. I am persuaded that my meaning will be better apprehended if I supplement my disquisition by an outline of an investigation of my own. The seeming egotism must be condoned, for it is manifestly impossible for me to trace out the actual course of observation and reasoning in the case of another's work.

To guard against possible misapprehension it is necessary to emphasize the fact that the following discussion contains an outline merely of its subject. Its subject is a certain geologic uplift that has been observed in Utah. To render it intelligible to those who are unacquainted with the literature of the geology of Utah, it will be introduced by a short account of Lake Bonneville.

The basin of Great Salt Lake lies in a region of mountains; to picture its character to your mind, conceive a plain the surface of which is embossed by parallel ridges of moderate length, from fifteen to twenty-five miles apart, and from 2,000 to 6,000 or 7,000 feet high. Conceive further that portions of this plain are uplifted, together with their mountain ridges, so as to enclose a basin 150 miles in either dimension, and you have the general structure of the district in question. The debris washed down from the mountains has for ages accumulated in this depression, so that the central-lying mountain ridges are nearly buried; indeed there is reason to suspect that some of them are quite buried, a plain of fine silt being spread smoothly over them. Great Salt Lake itself lies on the east side of the basin; the western half, which is only a few feet higher, is a saline desert.

In the last geologic epoch—the Glacial Epoch—the lake expanded so as to fill the basin to overflowing. The water surface was then very much larger, and as its area included the basins of several lakes now independent, it has been given a separate name. Lake Bonneville was very irregular in form; the mountain ranges of the basin ran long peninsulas from its north and south shores, and projected from its surface in numerous islands. The Quaternary winds, playing on its surface, dashed waves against its shores, and the spits and beaches and

cliffs wrought by these waves remain in a high state of preservation to testify to the position of the ancient water margin. Through the greater part of its extent this shore-line forms a conspicuous feature in the topography of the country, and is readily traceable. It has been actually traced out, surveyed, and mapped with much care, and our knowledge of the old lake is in many other respects definite and full.

Its width from a few miles east of Great Salt Lake to the west side of the Great Salt Lake desert was 125 miles. From the mountains on the north of the desert to those on the south its expanse was about the same, but it did not terminate with the southerly mountains. It extended through them in several straits and formed beyond a second and much smaller body of water. The main body was 1,000 feet deep, the minor body about 500 feet.

Manifestly, when this old shore-line was made, all parts of it lay in the same horizontal plane, with no other curvature than that which belongs to the figure of the earth; that is, all parts of it were level. If it is not now level—if some parts are higher than others, it seems equally manifest that there have been local elevations or subsidences of the land. It is to such differences of level in the shore-line as it stands, and to their interpretation, that I desire to call your attention.

As far as the eye can judge, the shore is still level, and so long as no measurements were made its horizontality remained unquestioned. The two geologists who were probably the first to measure its height recorded their results in language implying no suspicion that more than one determination was necessary.

It happened that in the year of my first exploration of the Bonneville area I saw the shore-line not only in the Salt Lake basin but in the more southerly basin, and that I passed from one basin to the other by a route that did not reveal their connection. In doubt whether two lakes were under observation or only one, I sought to answer the question by determining the height of the shore-line in each, my instrument for the purpose being the barometer. The verdict of the barometer was that the southerly shore-line was somewhat higher than the northerly, but the computations necessary to deduce it were not made until the mutual continuity of the two shore-lines had been ascertained by direct observation. The barometric measurement was therefore superseded as an answer to the original question, but it answered another which had not been asked, for it indicated that the ancient shore at one point had come to stand higher than at another. The postulate of horizontality was thus overthrown.

An hypothesis immediately took its place. It is one of the

great inductions of geology that as the ages roll by the surface of the earth rises and falls in a way that may be called undulatory. I do not now refer to the anticlinal and synclinal flexures of strata, so conspicuous in some mountainous regions, but to broader and far gentler flexures which are inconstant in position from period to period. By such undulations the Tertiary lake basins of the Far West were not only formed but were remodeled and rearranged many times. By such undulations the basin of Great Salt Lake was created. As to their cause, geology is absolutely ignorant, and she is almost absolutely silent. When it was ascertained that the Bonneville shore-line at two distant points had not the same height, the first hypothesis to suggest itself merely referred the difference to this gentle undulatory movement of the crust. As other hypotheses are to be mentioned, it will be convenient to christen this one the hypothesis of unexplained undulation.

A few years later the discovery was made that a fault had occurred along the western base of the Wasatch range of mountains since the Bonneville epoch. This range lies just east of Great Salt Lake, and the Bonneville shore is traced across its western face. The effect of the fault was to lift the mountain higher, with reference to the lake bottom, and to carry that part of the old shore-line upward. The amount of the uplift varied in different parts of the fault from ten to fifty feet.

This discovery was something more than the finding of a post-Bonneville fault; it was the discovery also of a new method of recognizing faults—of a peculiar type of cliff produced by faulting, which, though by no means obscure, had previously been overlooked by geologists. It gave rise to a new tentative explanation for the displacement of shore-line discovered by barometer, namely, that it arose by faulting; and it opened a new line of observation.

Two hypotheses were now under consideration, but they were not strictly alternative. Perhaps it would be better to say that the origination of the second not only gave an alternative but also modified the first. The Wasatch fault must affect the height of the shore-line, and wherever it crossed the shore-line that line must be discontinuous and exhibit two levels. The admission of disturbance by faulting was therefore compulsory, but faulting might or might not be sufficient alone. If it was not sufficient, then undulation might complement it. The modified first hypothesis was, undulation and faulting combined, the second, faulting alone—both undulation and faulting being themselves unexplained.

It was not difficult to devise tests. An instrumental level line might be carried along the old beach so as to ascertain whether it rose or fell in regions where no faults occur; or its

height might be carefully measured at two points and the difference of altitude compared with the total throw of the intervening post-Bonneville faults. The second of these tests was applied, and with success. By means of the surveyor's level the height of the old shore above the water surface at the shore of Great Salt Lake was measured at two points twenty miles apart. One of these points is on the Wasatch range near Salt Lake City; the other is on the next range west, the Oquirrh. The only post-Bonneville fault between them is that at the base of the Wasatch, and its throw is there about fifty feet, the west side having gone down. If then faulting is alone responsible for shore-displacement, the beach on the Oquirrh range should be fifty feet lower than that on the Wasatch. The measurement however showed it to be twenty-eight feet higher, and thus demonstrated a difference of seventy-eight feet to be referred to undulation.

Thus a step was made in advance, but the resulting position was not final, for the inquiring mind could find no satisfaction in the knowledge that crust undulation and crust faulting were conjointly efficient, so long as both these remained without explanation. No new hypotheses were at once invented, but it was determined to continue observation until the solitary phenomena at command were expanded into a group, and to seek new light in the classification of this group. As the basin was traversed in the conduct of the general investigation of the old lake, a search was made for the records of recent faults and at every opportunity the height of the shore was accurately measured. Six such measurements were made in the immediate vicinity of Great Salt Lake, the lake affording a common datum plane. Ten others were made on the lines of railways, where the leveling data of the railway engineers could be utilized. At some points the height was found greater than on the Oquirrh, at others less than on the Wasatch, the range from highest to lowest being 168 feet.

Faults were discovered at the bases of numerous mountain ranges, but none of them are so great as that along the Wasatch, and nearly all are very small. None were found associated with the half-buried mountains of the center of the desert, and yet on these same mountains are the highest shore records to which measurement was carried.

In general it was found that the displacements recorded by the shores have been much larger than the displacements demonstrated by faults, so that faulting can be appealed to in explanation of shore displacement only to a small extent. It was found that the throw of the faults was in some cases opposed in direction to the total deformation on the shore-line and in other cases coincident. For these reasons faulting was provis-

ionally regarded as a disturbing factor merely, and the deformation demonstrated by the measurements of shore-height was treated as simply flexural or undulatory.

To classify the shore-heights, as a basis for further hypothesis, they were platted on a map, and their grouping was compared with geographic features. It appeared that the highest measured points lay within the area of the main body of Lake Bonneville, that the lowest points lay at the extreme north and at the extreme south, that the eastern shore of Lake Bonneville in the vicinity of Great Salt Lake was intermediate in height, and that the single point determined on the western shore of the old lake agreed in height with the eastern shore. Unfortunately, the distribution of the measurements, which had been largely determined by the distribution of railroad lines, was not equable throughout the basin of the lake, and nearly the whole of its western shore was undetermined in altitude. When lines of equal altitude were drawn among the figures representing measurements, after the manner of the isobars on a Signal Service weather map, it was found that they were not fully controlled by the determined points; but when they had been given the most satisfactory adjustment, they contoured a figure of deformation which may be characterized as a low, broad dome, having its crest over the center of the main body of Lake Bonneville, and extending a subordinate member to the region of the southern body of the lake. One half of this figure was fairly inferred from the data of observation; the remaining half was imaginary and its drawing merely gave graphic expression to the hypothesis suggested by the incomplete contours—the hypothesis that the deformation stands in some necessary or causal relation to the lake and its disappearance.

Now it has been independently determined that the cause of the lake and the cause of its disappearance were climatic; it was not drained by the wearing down of its outlet, nor emptied by the unequal uplift of portions of its rim, but it was dissipated by evaporation. If then the disappearance of the lake and the deformation of the land are connected in a causal way the change in the lake was the cause, and the change in the land was the effect. How can we suppose the drying up of the water to have produced the up-arching of the plain on which the water lay?

In the attempt to answer this question three tentative explanations were suggested, and these will be stated in the order of their origination.

It is well known to geologists that in several instances a great formation thousands of feet in thickness consists wholly or chiefly of shore deposits. To account for them it is neces-

sary to suppose that the sea floor locally sank down as rapidly as the sediments were added. Conversely there is reason to believe that the adjacent continent, which by erosion furnished the sediment, rose up as rapidly as its surface was degraded. It is a favorite theory—at least with that large division of geologists who consider the interior of the earth as mobile—that the sea-bottom sinks in such cases because of the load of sediment that is added and that the land is forced up hydrostatically because it is unloaded by erosion. A similar theory might explain the up-arching of the desiccated bed of Lake Bonneville, for the unloading of 1000 feet of water from an area more than one hundred miles across would give to the supposed liquid interior an irresistible uplifting force. This was the first explanation to suggest itself.

The second suggestion did not spring from any geological theory consciously retained in memory, but I have since suspected that the germ of the idea may have been caught from a passage in Croll's 'Climate and Time.' It is this: The geoid of which the ocean's surface is a visible portion is not an ellipsoid of revolution, but differs from that symmetric surface by undulations which depend on local inequalities in the density and in the superficial configuration of the earth. The water level is everywhere normal to the plumb-line, but the plumb-line, as geodesy has shown, is subject to local deflection. Now the ocean itself is one of the attracting factors, and if the ocean were to be removed, the geoid would thereby be modified. The surface of Lake Bonneville was part of a geoid at a higher plane than that of the ocean surface, and the removal of the water of the lake unquestionably modified the local form of the geoid. Only at first blush the cause seems too small for the effect observed.

The third suggestion relates to the distribution of temperatures beneath the surface of the earth. It is well established that the inner parts of the earth are extremely hot. The outer surface is relatively cool, and in the intermediate region there is a gradation of temperatures. The isogeotherms, or planes of equal temperature, are not even surfaces, but undulate in response to variations of conductivity and of superficial temperature. At the poles, where the external surface of the crust is exceptionally cold, the isogeotherms lie lower down than in warmer latitudes; and if a portion of the earth's surface undergoes a permanent change in temperature, the influence of this change is propagated slowly downward through the crust, and the isogeotherms are locally raised or lowered. Where they are raised, the crust is locally expanded, and its surface is uplifted; where they are depressed the surface of the crust subsides. If, therefore, it can be shown that the temperature at the

bottom of Lake Bonneville was raised in connection with the dessication of the lake, we have a true cause of upward movement, and if we can show furthermore that the temperature of the surrounding region was not equally raised, we have at least a qualitative explanation of the differential uplift, the phenomenon to be accounted for.

It is now several years since these explanations were first suggested, and subsequent reflection has developed no others. While all of them appear perfectly rational, only a very slight inspection was necessary to raise a doubt as to the quantitative sufficiency of the second and third. It was therefore determined to ascertain as accurately as possible the maximum change which might be ascribed to each of the three suggested causes, and to compare it with the actual change. The actual change is susceptible of various statements. If we consider only the measurements on the margin of the main body of water, and in its center we find a difference of 100 feet; by including observations on outlying bays we get a maximum difference of 168 feet; and a study of the peripheral slopes of the uplift suggests that they extend somewhat beyond the boundaries of the lake. Crude extrapolation gives 200 feet as a maximum estimate of the height of the crustal dome.

Take first the hypothesis that the crust of the earth, floating on a molten nucleus, rose up in the region of the basin when its weight was locally diminished by the removal of the water of the lake. The weight of the load removed is measured by the depth of the water before evaporation, 1000 feet. The theory supposes that as the crust rose there flowed in beneath enough molten rock to replace the weight of the evaporated water. If the rock was very heavy, a layer of moderate depth was necessary; if it was less heavy, more was required; but in any event the thickness of the introduced layer must be equal to the amount of the superficial uplift. It is known that the density of the earth's material increases downward, for the mean density of the earth, expressed in terms of the density of water, is about 5·5, while that of the upper portion of the crust is about 2·7. Nothing is known however of the law under which the density increases, and nothing is known as to the depth of the zone at which matter is sufficiently mobile to be moved beneath the Bonneville basin. We may, however, indicate limits, and I think this is fairly done by assuming that the density of the introduced matter was not less than 3, nor more than 5·5. If it was 5·5, the uplift consequent on the evaporation of 1000 feet of water would be 182 feet. If it was 3, the uplift would be 333 feet. Now it has already been stated that the greatest value observation suggests for the amount of the uplift is 200 feet. The postulate is therefore abundantly competent in a quantitative way.

To evaluate the effect produced under the second hypothesis (the hypothesis, that is, that the geoid represented by the water surface of Lake Bonneville has been deformed by the withdrawal of the attraction exerted by the water itself) it is necessary to employ mathematical analysis of a high order. As my schooling in mathematics did not qualify me to undertake this, I submitted the problem to an eminently competent colleague, who has solved it rigorously and deduced for the deformation of the geoid within the area of Lake Bonneville a maximum amount of two feet. The second explanation is therefore eliminated from consideration, because quantitatively insufficient.

It remains to consider the rise of the isogeotherms, and to evaluate the resulting elevation of the basin. It has been established by numerous observations that in all lakes having a depth as great as 1000 feet, the temperature at the bottom is about 39° F. This depends upon the fact that water at that temperature is heavier than at any other, and having once reached the bottom of a deep lake, it is withdrawn from the circulation to which the upper layers are subject, and remains undisturbed. The meteorological records show that the mean annual temperature of the desiccated basin of Lake Bonneville at the present time is 52°. The change from a humid to an arid condition has therefore raised its temperature 13°. The temperature of the surrounding regions has at the same time undergone a change, of which we have no precise estimate. The epoch of Lake Bonneville was the Glacial Epoch, and the local climate was then in all probability cooler. If it was 13° cooler, the isogeotherms would be no more affected at the center of the basin than at its margins, and there would be no differential elevation. If it was cooler by less than 13° a differential uplift would occur. For the sake of giving this uplift a maximum value, we will assign a very small figure to the general change of temperature, namely 3°, and assume that the differential change with respect to the basin was 10°. A formula devised by Fourier enables us to estimate the rise of the isogeotherms, if only we know the conductivity of the material of the earth, and the time which has elapsed since the Bonneville shore line was carved. Then, if we know additionally the rate of expansion of rock for a degree of temperature, we are able to estimate the upheaval. Sir William Thompson has determined experimentally a coefficient of conductivity. The late Prof. Bartlett, of West Point, has determined the coefficient of expansion for several building stones, which may be assumed to represent the crust beneath the Bonneville basin. We do not know how these coefficients are affected by high temperatures and great pressures, such as exist deep in the crust, and an element of uncertainty attaches for that reason.

In order to obtain a maximum result despite this uncertainty, I have made an extreme assumption in regard to time. The shore line of Lake Bonneville is in a wonderfully perfect state of preservation. While one stands upon it, it is easy to believe that it is but a few centuries old, and the geologist, accustomed as he is to the contemplation of eons of time, hesitates to estimate its antiquity in greater units than thousands or at most tens of thousands of years. When therefore we postulate its antiquity at one hundred millions of years, we pass so far beyond the range of probability as to protect ourselves against a possible underestimate. With these data the computation has been made, and it has been ascertained that a maximum uplift of 36 feet* can thus be accounted for. Since observation shows an uplift of not less than 100 feet, the thermal explanation is shown to be entirely inadequate; and if we were able to substitute for our imperfect data the actual data, we should probably find the computed uplift too small to be taken into consideration.

If therefore we admit that the removal of the water of the lake was the cause of the upheaval of the lake-bottom, there seems no way to avoid the conclusion that the efficient *modus operandi* was an upbending of the solid crust of the earth, caused by hydrostatic pressure communicated through a mobile substratum. But we are far from being forced to that admission. The coincidence in locus of the uplifted dome and the Quaternary lake may have been fortuitous; or there may even have been no coincidence, for the contoured figure of deformation was in part supplied by the imagination; and in either of these cases we can fall back on the agnostic hypothesis of unexplained undulation. In the present state of observation and inference the hypothesis of the hydrostatic restoration of equilibrium by the underflow of heavy earth-matter is the only explanation which explains, and none of the observed facts antagonize it; but the alternative hypothesis is not barred out.

To reach a satisfactory conclusion more observation is necessary, and this discussion of the subject would be premature were it not that the necessary observation is very expensive, and there is no immediate prospect that it will be supplied. It is fitting, however, that the desirable lines of research be pointed out.

The undertaking that promises most is an exhaustive hypsometric survey of the Bonneville shore line, including all bays and islands. If this were executed, it would be possible to deduce

* In the original paper, as read, 12 feet instead of 36 were erroneously given. A friend has since pointed out that the estimate of 12 feet includes expansion in the vertical direction only, whereas the coincident horizontal expansion would almost necessarily be converted into uplift.

a much more satisfactory expression of the shape of the uplift, and to determine either that it is intimately related to the form of the body of water removed, or that it is not so related. If the relation were demonstrated, the observations might so far indicate its nature as to render possible an evaluation of the rigidity of the earth's crust.

Another profitable method of continuing the inquiry would be to make a similar investigation of the shore of another extinct lake, for example, the one to which Clarence King has given the name of Lahontan, and which ranks second to Lake Bonneville among the Quaternary lakes of the Great Basin. If in a second instance the center of the desiccated lake were found to be the locus of upheaval, the hydrostatic theory would be practically established.

It is hardly necessary for me to assure you that my personal regret in abandoning this research at its present stage is very great. I have discussed it as an investigation of the deformation of the Bonneville basin, but it has a broader meaning. The condition of the interior of the earth is one of the great problems of our generation. Those who have approached it from the geologic side have based a broad induction on the structural phenomena of the visible portion of the earth's crust, and have reached the conclusion that the nucleus is mobile. Those who have approached it from the physical and astronomic side have reached the conclusion that the nucleus is rigid. Here seems an opportunity for a crucial observation. If the crust of the earth floats upon a fluid nucleus, the evaporation of Lake Bonneville, by lifting from it a great weight, must have produced an uplift of determinate form. If the whole earth is solid, such a result could not have been wrought. The decisive phenomena are known to exist, and to be accessible, but they are scattered over a broad desert, and they can be gathered in only at the cost of much money and great labor.

Art. XXVIII.—*Nova Andromedæ*; by Asaph Hall.

(Communicated by Geo. E. Belknap, Commodore U. S. N., Superintendent.)

At the end of last August Dr. Hartwig, of Dorpat, announced the appearance of a new star in the great Nebula of Andromeda. This announcement aroused much interest and brought out a great deal of speculation on the origin of these new stars, and on the nature of the nebulæ and their connection with our sidereal system. Quite naturally in such a case,

much of this speculation was of the wildest character, and some very uncertain inferences were drawn. The new star has now faded away to a mere speck of light, visible only in our largest telescopes. Unfortunately, and perhaps unavoidably, we have learned but little more from this new star concerning the nature of nebulæ and variable stars than we knew before its appearance. But the history of its discovery, its observation, and of its gradual fading out, is interesting enough to hold our attention for a little while.

The appearance of the new star was announced by Dr. Hartwig on August 31st, but it had been seen by him on the preceding night with a small telescope, and he had suspected some change in the nebula as early as the 20th of August, but bad weather, and a lack of instrumental means for making the matter certain, deferred the announcement until the 31st. From the various estimates at that time the star was probably a little brighter than the seventh magnitude, or just below the limit of visibility to the naked eye. The announcement of course turned a host of observers to the new star, and many erroneous estimates and statements were made. Some observers estimated the brightness far too great, and several, on account of errors in the observations, announced that the new star was moving with an enormous velocity. It required the lapse of a few weeks to clear away and correct all this error.

After Dr. Hartwig's announcement, it appeared that several others had seen the new star, but for some reason, perhaps want of familiarity with this nebula and lack of confidence that a new star had really appeared, they did not make a public announcement. Thus the Baroness Podmaniczky, of Eastern Hungary, saw the new star on August 22d or 23d, with a $3\frac{1}{2}$-inch comet seeker, and called the attention of a visitor to it, but they do not seem to have been certain that the object was new. This lady looked at the nebula on August 13, and did not see the new star. Mr. H. S. Moore, of McKinney, Texas, saw the new star on August 30. The circumstances indicate that this is a *bona fide* observation. A really independent discovery was made by Freiherr von Spiessen, of Winkel im Rheingau, who found the new star on August 30, and immediately sent a postal card to the Bonn Observatory where it was received on the evening of the 31st, or about a day before Hartwig's announcement. Mr. Isaac W. Ward, of Belfast, Ireland, claims that he saw the new star on August 19, when it was of the $9\frac{1}{2}$ magnitude. Finally, Professor Ludovic Grelly, of Rouen, says that he saw the new star on the 17th of August, and showed it to several friends and students. On the other hand Mr. Tempel, of Florence, Italy, who has done much work on nebulæ, and who is well acquainted with the great nebula

of Andromeda, says that he is confident there was no star in the place of the new one which was easily visible in his telescope on the 15th and 16th of August. This testimony is important, and serves to fix the time of the appearance of the *nova*, or at least the time it became an easy object in telescopes, within very narrow limits. This time must have been between the 16th and 20th of August, 1885. It is probable that the star increased rapidly in brightness, since on August 31st it was of the seventh magnitude. It never, I think, became much brighter, though statements were made early in September that it was of the second or third magnitude, and easily visible to the naked eye. Its diminution of brightness began about August 31, and has gone on pretty steadily until the present time. There have been several attempts to show that there were fluctuations in its brightness, but these are so uncertain that we must wait for the complete evidence.

At first, the position of the new star was confounded with that of the bright point of the nebula, and as this mistake added interest to the discovery, it was some time before it could be generally corrected. The coincidence with the nucleus of the nebula seemed to indicate that we had before our eyes the formation of a sun from nebulous matter, and hence a strong proof of the nebular hypothesis. Our popular astronomical writers were not slow to improve the occasion, but in fact the new star never coincided with the nucleus. The assumption of any intimate physical connection of the new star with the nebula has been given up by Vogel, of Potsdam, and Hasselburg, of Pulkowa, who have examined its spectrum. Within the limits of this nebula there can be counted from fifteen hundred to two thousand telescopic stars, and one of these has proved to belong to the class of temporary stars, so-called, of which we have records of from 20 to 30. What causes these stars suddenly to flame out, and then to fade gradually away we do not know; and so far as I know, there is hardly a plausible theory.

I first saw this new star on September 6, when its magnitude seemed to me 7½, and the star had a decidedly ruddy tinge. This color lasted but a few weeks, and as the star grew fainter it became of a white color. My observations have been continued until February 7th of the present year, and probably the star will be visible in the 26-inch refractor after the present moon has passed. It is now very near the limit of visibility in our telescope, or of nearly the sixteenth magnitude. The passage from the seventh magnitude to the sixteenth corresponds to a very great change of brightness, since it is the passage from the limit of visibility to the naked eye to that in a 26-inch telescope. Several hypotheses were proposed

to account for this wonderful star, and one that seemed to me quite ingenious is that of Mr. Monck, of Ireland, who assumed that this star is one of the swiftly moving ones that in rushing through the nebula had been set on fire, like a meteor in our atmosphere. Led by some such suggestions, and also by that of Professor Peters that it would be interesting to test the parallax of such a star, on September 29th I began some measures of the new star by referring it by means of polar coördinates to a known star of the eleventh magnitude, distant from it a little less than 2′. These measures have been continued until the present time, although of course as the star became extremely faint the measures became difficult and less accurate. I do not think my measures show any proof of a parallax, though they indicate perhaps a diminution of the distance, and even this may be sufficiently accounted for by variations in the light and color of the new star, since such variations would be likely to affect the measures. My measures are given in the following table, and I have added the parallactic coefficients computed from the formulæ,

$$\text{Coefficient for Angle} = [9{\cdot}7932].\ \cos(\theta - 172^\circ\ 21')$$
$$\text{Coefficient for Distance} = [9{\cdot}9810].\ \cos(\theta - 284^\circ\ 46')$$

where θ is the longitude of the sun; p denotes the observed angle of position, and s the observed distance.

Date.			p.	Coeff.	s.	Coeff.	Remarks.
			°		″		
1885,	Sept.	29	82.32	+0·602	109·98	−0·132	9th mag., sky hazy.
	Oct.	3	82·24	0·589	109·96	0·067	
		6	82·30	0·578	109·75	−0·017	Less than 9th mag.
		9	82·17	0·565	109·68	+0·032	10th mag.
		15	82·34	0·534	109·84	0·131	
		25	82·17	0·471	109·60	0·291	10·7 mag.
		26	82·25	0·464	109·57	0·307	
		31	82·36	0·426	109·80	0·384	
	Nov.	24	82·21	0·205	109·37	0·702	On Nov. 12th, mag. same as star of comparison.
	Dec.	2	82·21	0·122	109·27	0·783	
		6	82·28	0·079	109·31	0·818	11·5 mag.
		12	82·13	+0·014	109·27	0·862	
1886,	Jan.	1	82·25	−0·199	110·18	0·940	Very faint, misty; 15th mag.
		2	82·30	0·210	109·39	0·940	13th–14th mag.
		7	81·37	0·262	109·66	0·940	Very faint.
		30	82·27	0·460	108·67	0·846	Very faint, 16th mag.
	Feb.	7	82·17	−0·513	109·50	+0·779	Very faint, 16th mag.

The observations have been corrected for differential refraction, but the small reduction to a common epoch has been omitted. A comparison of the observed quantities with the coefficients shows little evidence of parallax. The observation of January 7 was made by Lieut. W. H. Allen, U. S. N., and

he estimated the brightness of the new star on November 12 to be the same as that of the star of comparison. Such a relative estimate is good, but the absolute magnitudes are uncertain. The limit of visibility in a 26-inch telescope is 16·3 magnitudes, and the *nova* is now so near this limit that accurate measures can no longer be made.

The great nebula of Andromeda is easily visible to the naked eye, and doubtless it was known to the astronomers of very ancient times. Those astronomers watched the heavens with unaided vision much more carefully than do modern astronomers, and they were far better acquainted with the constellations. The old astronomers had a theory that this nebula was variable both in form and brightness. They had poor means of judging of its form, but it is possible that their estimates of brightness may be more trustworthy, and that our new star may be an old variable which has appeared before, causing the nebula apparently to vary in brightness. One of the best descriptions of this nebula is by an astronomer of the middle ages, Simon Marius in 1612, who says it resembles a candle shining through a horn. It has a bright nucleus, around which is the soft, fleecy-looking nebulous matter, shading off very gradually from the center. This nebula has an angular extent of two degrees. No parallax has yet been found for a nebula; but if we suppose them to be as distant as the brightest of the fixed stars, and to have a parallax of a quarter of a second of arc, we may get some idea of the enormous extent of such a nebula as the great one in Andromeda. Making the preceding assumptions, its diameter will be about a thousand times as great as the distance of Neptune from the sun. Probably this estimate is less than the real diameter. That changes go on in such vast bodies we cannot doubt, for we see motion and change everywhere, but the distances are so great that small changes would pass without notice by astronomers on our earth. For this reason and also from the difficulty of making accurate drawings of such indefinite objects, we have as yet hardly any proof of changes in the forms of nebulæ.

U. S. Naval Observatory, 1886, Feb'y 12th.

ART. XXIX.—*On Some New Forms of the Dinocerata;* by W. B. SCOTT.

IN 1875, Professor Cope established the *Amblypoda* as an order of hoofed mammals, including as its two sub-orders the Coryphodons of the Wahsatch Eocene and the Dinocerata of the Bridger. This association of animals so divergent in appearance rests more especially upon the structure of the feet

and brain, and assumes that the two groups had a common ancestor, if indeed the one did not stand in an ancestral relation to the other.

If Professor Cope's hypothesis be correct we should naturally expect to find a series of forms connecting the two groups and leading to a common term, showing how the large and most curious Dinocerata could be closely related to the smaller and much less striking Coryphodons. In the latter there is a complete set of upper incisors and a canine tusk of moderate size; the lower incisors possess but a single lobe and the lower canine is erect and as large as the upper tusk, which it opposes. In the Dinocerata the upper incisors are entirely wanting, the canine is converted into a great sabre-like tusk; while the lower canine is very small, shaped like the incisors and functionally belonging to the latter, which present the extraordinary peculiarity of having compressed bilobed crowns. In the Coryphodons the cranium is nearly flat on top, there being no sagittal crest, and there are none of the great osseous protuberances which give such a characteristic and peculiar appearance to the skull of the Dinocerata, although in some species of Coryphodon (e. g. *elephantopus*) there are small swellings which indicate these protuberances; there is also a beginning of the supra-occipital and parietal crests which in Uintatherium reach such great proportions. The nasals are thin, short and weak, ending anteriorly in a point and strikingly different from the very long and heavy nasals of the Dinocerata.

The only form hitherto known which in any way helps to fill the gap between the two sub-orders of the Amblypoda is the genus *Bathyopsis* Cope, from the Wind river or lowest Bridger beds of Wyoming. Of this genus only the lower jaw has been found; but the important point is brought out that the lower canine was a large erect tooth, probably opposing the upper canine and not forming a part of the incisor series as is the case in Uintatherium. The form and position of this tooth make it exceedingly probable that the upper canine had not reached the great sabre-like proportions found in the other Dinocerata. It is not certain whether the presence of the first premolar is a constant feature or simply indicates a milk-molar persisting longer than usual. The latter is so frequently the case, that it is impossible to attach any value to its occurrence in an isolated specimen.

The Princeton Expedition of 1885 had the good fortune to discover, in the Bridger beds of Henry's Fork, Wyoming, another missing member of this hypothetical series. The new genus, for which I propose the name *Elachoceras*, may be briefly defined as follows: animals allied to Uintatherium, without upper incisors, and having six molars of the Uintatherium pattern, and large upper canine tusks; but without nasal pro-

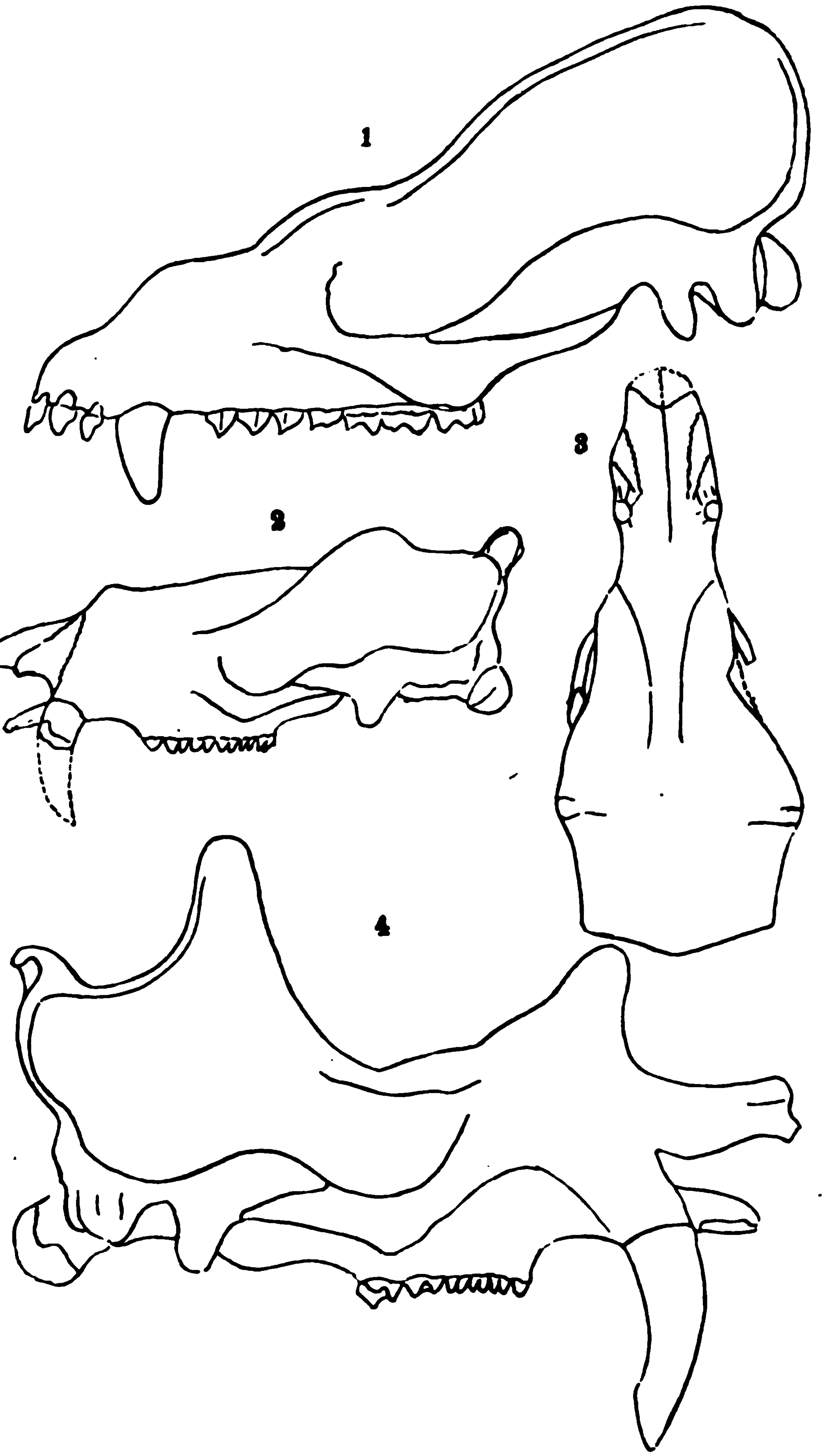


FIG. 1.—Skull of *Coryphodon*, left side (after Cope). FIG. 2.—Skull of *Elachoceras parvum*, left side. FIG. 3.—The same, top view. FIG. 4.—Skull of *Uintatherium alticeps*, right side.

tuberances and having only rudiments of the maxillary and parietal protuberances. The supra-occipital is pierced by two large venous foramina, placed one on each side of the median line.

The species may be called *E. parvum* and is defined by the low supra-occipital and parietal crests, the long and very narrow muzzle, the presence of a single tubercle on each molar tooth, and the small size of the animal (see figs. 2 and 3). It might at first sight be supposed that we have here the skull of a female or young animal, which would account for the very small size of the so-called horns. But the complete and somewhat worn dentition and the state of the sutures at once negative the supposition that the animal was not entirely adult. The question of sex is rather more difficult to decide. Professor Marsh has shown that the skulls of female Dinocerata are characterized by small canine tusks and less prominent "horns." Professor Marsh very kindly allowed me to make a careful examination of the female skulls in his collection, which immediately convinced me that Elachoceras is not a mere sexual variety of Uintatherium, as I had suspected might be the case. The tusks are not only proportionally but actually of much greater diameter than in very much larger females. In point of fact, in proportion to the size of the skull, the tusks of Elachoceras are nearly if not quite as large as in the largest Uintatherium males. On the other hand the protuberances are very much smaller than in any known female and the nasal pair seems to be altogether absent. I cannot, however, state this with entire certainty, as the extreme tip of the nasals is broken off, but the fact is more than probable for these reasons: (1) The nasals are preserved beyond the tips of the premaxillæ, where in all other known Dinocerata the swelling for the protuberance is visible. (2) In Elachoceras the nasals are exceedingly thin and weak, whereas the nasals of Uintatherium are strikingly strong and heavy; in the former there is no trace of any thickening or swelling at the tips of the bones.

Such a combination of large tusks with rudimentary protuberances is not what we find in any known female and seems to remove all reasonable doubt as to the sex of the specimen before us. If this be granted, the distinction of the genus from Uintatherium necessarily follows.

It is interesting to note that Elachoceras very much resembles the young specimens of the Dinocerata, especially the one described and figured by Professor Marsh (see his Monograph, p. 15, fig. 8), though even in this young skull the protuberances are much more prominent than in Elachoceras.

Another possibility is that in Elachoceras we have the missing skull of Bathyopsis; but this I consider to be extremely improbable, from the very peculiar character of the molar teeth

in the latter, which would almost certainly imply a similar modification of the upper molars. Another reason against such a reference comes from the presence of the large canine tusk of the upper jaw, which, as we have already seen, had probably not attained such dimensions in Bathyopsis. With the exception of the last named genus, Elachoceras is the smallest known member of the group, the skull measuring only about 22 inches in length.

In the same locality, though at a somewhat higher level, was found the large Uintatherium skull shown in fig. 4, which undoubtedly represents a new species of that genus, *U. alticeps.* Nothing is more hazardous than making new species of the Dinocerata, for, as every one who has studied them knows, they are extraordinarily variable, and if judged by the usual criteria almost every skull would constitute a distinct species. However, by carefully comparing nearly forty skulls, I have found that certain characters may be depended upon to determine the various species, not being subject to such apparently capricious variation. Among these may be mentioned the general shape of the skull, the *position* (not shape) of the "horns," the shape of the occiput, the character of the tusk, and the structure of the molar teeth.

Examined with reference to these characters the skull shown in fig. 4 is unquestionably distinct. It is one of the broad-headed species, with remarkably high occiput, the parietal protuberance is in *advance* of the post-glenoid process. (I have found the best method of exactly determining this point is to connect the tip of the pre-maxilla with that of the post glenoid process and erect perpendiculars on this line.) The molar teeth are much as in *U. lucare,* but without tubercles on the anterior cingulum; there is a pair of small tubercles at the entrance of valley of the last molar. The lunar has no facet for the trapezoid. The great height of this skull, as compared with its length, suggested the name *alticeps.*

The value of the tubercles on the molar teeth as a specific character has been questioned, but I am inclined to think that considerable importance must be attached to them. For example, the very large series of Palæosyops remains in the Princeton Museum, ranging from species smaller than the sheep up to those as large as the rhinoceros, show without exception a small tubercle between the anterior cusps of the upper true molars. The tubercles on the teeth of the Dinocerata show no such constancy as this, it is true; nevertheless they are sufficiently constant to rank as species characters.

These notes are preliminary to a much fuller account which will shortly appear in a paper on the variations of the Dinocerata.

Geological Museum, Princeton, N. J., Feb. 12, 1886.

SCIENTIFIC INTELLIGENCE.

I. CHEMISTRY.

1. *On the Volatility of Sulphur and Mercury.*—It is well-known that in the drying rooms of powder works where gunpowder is dried at a carefully regulated temperature which never surpasses 60° to 65°, there is always a peculiar odor somewhat recalling that of sulphur dioxide. By placing plates of glass in such a room at some distance from the mass of powder, BERTHELOT has succeeded in obtaining a distinct sublimate deposited on the glass, which gave, on analysis, sulphur 97·84, potassium nitrate 0·90, carbon and undetermined matters 1·26. Hence it is not an oxide but pure sulphur which has thus been sublimed at 60°, mixed, mechanically no doubt, with a minute quantity of the other constituents of the gunpowder. The vapor tension corresponding to this slow sublimation, effected 380° below the boiling point under normal pressure, is not appreciable by manometric measurements. It should be zero or sensibly so at the ordinary temperature, since no deposition of sublimed sulphur is observed in glass cases or tubes in which sulphur has been kept for many years. The permanent sharpness of the edges of sulphur-crystals in collections, also confirms its feeble volatility. The volatility of mercury, whose tension at 20° is only 0·0268^{mm}, the author illustrates by the fact that in his laboratory there is a mercurial trough and at a distance of 2·5 meters from it a glass case containing a bottle of iodine. After some years, Berthelot noticed that the neck of this bottle above its junction with the stopper was covered with red mercuric iodide. No ammonia nor volatile acid were kept in the case.—*Bull. Soc. Ch.*, II, xlv, 114, February, 1886. G. F. B.

2. *On Germanium, a new non-metallic Element.*—In the summer of 1885, Weisbach gave the name argyrodite to a new mineral existing in a rich silver ore from the Freiberg mines. On undertaking its analysis, WINKLER found it to consist of 73 to 75 per cent of silver, 17 to 18 per cent of sulphur, 0·21 per cent of mercury and traces of iron and arsenic. But in spite of all possible care, the loss in the analysis amounted to 6 or 7 per cent; and this without the detection by qualitative analysis of any other substance. Finally, the discrepancy was traced to the existence of a new element in the argyrodite, analogous to antimony, for which the author proposes the name Germanium. When the mineral is heated in a current of hydrogen, a black crystalline pretty easily volatile sublimate is obtained, which readily fuses into brownish-red drops, and which, besides a little mercuric sulphide, is essentially germanium sulphide. It dissolves readily in ammonium sulphide, and is precipitated by hydrogen chloride as a snow-white precipitate, readily soluble in ammonia. Heated in a current of air or treated with nitric acid, it gives a

white oxide, non-volatile at a red heat, soluble in alkali solutions, and reprecipitable by acids. Both oxide and sulphide are reduced by hydrogen and yield an element of a gray color and moderate luster resembling arsenic, volatile at a full red heat, somewhat more difficultly than antimony. Its vapor condenses in small crystals resembling iodine. Heated in a current of chlorine a white, easily volatile chloride is produced more volatile than $SbCl_3$ and whose aqueous solution is precipitated white by H_2S, after acidifying. The author has not yet determined the atomic weight, but suggests that the new element may fill the gap in the periodic system between antimony and bismuth.—*Ber. Berl. Chem. Ges.*, xix, 210, February, 1886. G. F. B.

II. Geology and Mineralogy.

1. *The Geology of Natural Gas in Pennsylvania and New York;* by C. A. Ashburner.—Mr. Ashburner observes that the oil and gas-yielding regions of Pennsylvania are geologically one. The borings yielding gas and oil go down to rocks in the Carboniferous and Devonian. About 30 miles west to northwest of Pittsburgh, at Smith's Ferry and Slippery Rock, the wells reach the base of the Coal-measures and Berea grit. To the north of Pittsburgh, 25 to 30 miles, they reach the Venango (Devonian) sands; and 30 miles S. 65° E. of Pittsburgh at Pleasant Unity, 31 S. 12° E, at Dunlap Creek, 45 m. to 48 m. south, at Whiteley Creek and Dunkard Creek, they go down to the Mahoning sandstone—the Lower Barren Coal-measures. The occurrence of accumulations of gas is stated to depend on the porosity of the rocks, the extent to which the rocks below the porous sand rock are cracked; the dip of the beds and the position of the anticlines and synclines; the relative proportion of water, oil and gas in the gas-bearing sand-rock; and the pressure under which the gas exists below.

The dip of the beds is very small, generally but 20 to 35 feet per mile, and that of 75 to 100 feet of the rarest occurrence. Of the three principal horizons yielding gas, (*a*) the Venango first oil-sand (or its probable representative) is 1800 to 1850 feet below the Pittsburgh coal bed, and believed to be in the Catskill formation; (*b*) the Sheffield gas-sand, the lowest in Warren Co., is of Chemung age; and (*c*) the Bradford oil-sand, which is 1757 feet below the base of the Pottsville conglomerate (or the lowest member of the Productive Coal-measures) is undoubtedly of Chemung age. But gas is obtained also from other horizons, up to that of the Mahoning sandstone, 500 feet above the Pittsburgh coal-bed. The gas is believed to have been formed in beds underlying the sand-rock from which it comes. The wells are commonly along the axes of synclines, but this position, Mr. Ashburner says is not universal.—*Amer. Inst. Mining Engineers*, Sept., 1885.

To the above facts from Mr. Ashburner's report, it may be now added that the very copious gas well recently opened at Findlay,

Ohio, is stated to descend into the Lower Silurian, and to afford gas at the rate of 40,000,000 cubic feet a year. The roaring of the escaping gas can be heard for five miles.

2. *Existing Glaciers in the United States;* by I. C. RUSSELL, U. S. Geol. Survey. From the 5th Annual Report of the Director, Major Powell. 1883–84. pp. 309 to 355. Washington, 1885.—Mr. Russell's Report, with its fine illustrations, is of interest to the country as well as to geological science. It gives the first connected account of the glaciers of the United States, and illustrates the subject with excellent views of some of the glaciers and glacier-bearing mountains from photographs. The glaciers have been called glacierets, because of their small size; but they have, still, as the views and descriptions show, the characteristics of those of greater extent. Mr. Russell's personal observations were made in the Sierra Nevada, on Mt. Dana, Mt. Lyell, and at other points in the High Sierras between the latitudes 36½° and 38°, at a height of about 11,500 feet above the sea. The division into the nevé and glacier is made out, and laminated or ribboned structure, dirt-bands and terminal moraines described. The dirt bands are stated to be probably a result, as suggested by Professor William H. Brewer, of the concentration, at levels, of surface dust by the periodical meltings over the glacier. The account of personal observations is followed by the earlier descriptions of the same glaciers by Muir and LeConte. Mr. Russell also gives in full Mr. Clarence King's description of the glaciers of Mount Shasta, made in 1870; and also an account by Mr. Gilbert Thomson, with fine views and a map of his observations, made on an ascent in 1883. To these are added Mr. Arnold Hague's account of the glaciers of Mt. Hood, in Oregon; Mr. S. F. Emmons's description of those of Mt. Rainier, in Washington Territory; notes on small glaciers of the Wind River Mountains, by Mr. W. H. Holmes; and on Alaska glaciers, by W. P. Blake and W. H. Bell. A general map of the Sierra Nevada region shows the positions of the existing glaciers, and also of the great glacier areas of former time.

3. *Upper Miocene* (*Loup Fork Beds*) *in Eastern Mexico.*—These beds, first described by Prof. de Castillo in 1883, occur on the borders of the States of Hidalgo and Vera Cruz. They have been found by Prof. Cope to afford remains of species of Protohippus, Hippotherium, and Mastodon, and probably of Procamelus; and others of Dicotyles are announced by de Castillo. The area is at least eighteen miles by six, and the thickness of the formation not less than 2,000 feet. It is intersected by the valleys of tributaries of the Tuxpan and Benados rivers, some of which are narrow gorges 1500 deep. Several thin beds of coal occur in it. This, Mr. Cope states, is the most southern point yet discovered of the Loup Fork beds.—*Amer. Nat.*, 1885, p. 494.

4. *New Carboniferous Arachnidan from Arkansas.*—Prof. S. H. SCUDDER refers to the Arachnidan genus *Anthracomartus* of Karsch, a fossil, somewhat trilobite-like in form, which he names

A. trilobitus. He observes that the *Brachypyge Carbonis* described by Woodward as the abdomen of one of the Brachyuran Crustacea is probably the abdomen of an Anthracomartus.

5. *Revision of the Palæocrinoidea* by C. WACHSMUTH and F. SPRINGER.—Part III of this important memoir published in the Proceedings of the Academy of Natural Sciences, has been completed. It covers 138 pp. 8vo, and is illustrated by plates IV to IX inclusive.

6. *Geology — Chemical, Physical and Stratigraphical;* by JOSEPH PRESTWICH, M.A., F.R.S., F.G.S., Prof. Geol. Univ. Oxford. In two volumes: Vol. I, *Chemical and Physical Geology.* 477 pp. 8vo.—Professor Prestwich's long labors in geology have supplied him with much material of his own observation for his geological treatise, and have enabled him to prepare a work that will contribute largely to the progress of the science. The volume now issued, after an introductory chapter, takes up the subject of the constituents of the earth's crust—its rocks. A review of the animal and vegetable kingdoms follows. Afterward the work treats of the formation of sedimentary deposits and the atmospheric and other agencies concerned, of ice-action, volcanoes, earthquakes, and coral islands. Then follow chapters on the disturbances of rocks with their effects, on mountain-ranges, on metalliferous deposits and veins, on igneous rocks and metamorphism. The various principles of the science are explained through well-selected facts and illustrated by numerous excellent figures, many of which are new to text-books. Among the latter, the one of the interior of Kilauea, we should like to modify. Besides figures in the text, there are also folded plates of sections, and three folded maps of the world, which add much to the value of the work. Of the latter, one is a colored map of the geological formations; another, colored, shows the oceanic currents and the distribution of coral reefs and islands; the third gives the distribution of volcanoes. The volume is from the Clarendon Press, Oxford.

7. *Artificial minerals.*—M. A. DE SCHULTEN, who has already accomplished many interesting results in chemical mineralogy, has recently succeeded in forming artificially the hydrous iron phosphate compound, $Fe_2P_2O_8+4aq$, which exists in nature as the mineral strengite; the rose-colored crystals obtained had a specific gravity of 2·74 and unlike strengite seemed to be monoclinic in crystallization. The method employed was to heat in a sealed tube, at 180° to 190° C., 26 cc. of a solution of the salt Fe_2Cl_6+12aq with 4 or 5 cc. of a solution of a specific gravity 1·578.

The same chemist has formed a hydrate of magnesium in small distinct hexagonal crystals (the mineral brucite), and also made a crystallized hydrate of cadmium, in flattened hexagonal prisms, optically uniaxial.

8. *Palæontology of New York;* by JAMES HALL. Vol. V, Part II, Lamellibranchiata.—The Plates of Vol. V, Part I of

Professor Hall's volume of plates of the Palæontology of New York, illustrating the Lamellibranchiata of the Upper Helderberg, Hamilton and Chemung groups, containing, with a few omissions, 80 plates, was issued in 1883, and is noticed in this Journal for that year (vol. xxv). Since then, Plates 81 to 92 inclusive have appeared, and now we have Plates 35 and 42, and 93 to 96 inclusive. The text of the second part of Vol. V, Part I, has also been issued, making the whole complete. Professor Hall states that the number of species of American Paleozoic lamellibranchs now known is over 1250; and that nearly half of this number have been collected in New York from the Trenton and later Paleozoic strata, and 500 from those above the Oriskany. The study of the species was a work of great labor and difficulty, and Mr. Hall is to be congratulated that the printing is finished. All paleontologists will rejoice with him, and give due honor to him and to the State of New York for this very valuable contribution to American science.

The Annual Report for 1882, of "the State Geologist," Mr. Hall, (in 4to, instead of the usual 8vo form), is made up chiefly, after a paper on the mode of growth of Fenestellæ, of plates of Fossil Corals and Bryozoans of the Lower Helderberg and Bryozoans of Upper Helderberg, 33 in number, and 28 plates illustrating the genera of some families of Brachiopods, being part of a revision of the Paleozoic genera of this group—portions of volumes of great paleontological interest yet to be published.

III. BOTANY AND ZOOLOGY.

1. *Botanical Necrology for* 1885.—Supplemental to the bibliographical notices given in the January number of this Journal, pp. 13–22, we should record the following obituaries:

JEAN-ETIENNE DUBY, long one of the Genevese clergy and not undistinguished as a botanist, died at Geneva, Switzerland, November 24, 1885, at the age of 88. In the year 1828 he edited the second edition of DeCandolle's Botanicon Gallicum, which served an important purpose as the manual of French and Swiss botany for many years. In 1844 he produced his memoir on the *Primulaceæ*, and his elaboration of that family for the Prodromus. His other publications relate to the lower Cryptogamia. They began in 1829 with a paper on the application of the principles of taxonomy to a tribe of Algæ: the latest, that we know of, was upon some new or little understood *Musci*, and was published in 1869. With this venerable man passed away the last of the colleagues of Aug. Pyramus de Candolle.

The Brothers TULASNE. The elder brother, a botanist of remarkable acuteness and sagacity, LOUIS RENÈ TULASNE, was born on the 12th of September, 1815, and died at Hyères, on the 22d of December, 1885, twenty years after he had abandoned all scientific pursuits. CHARLES, born a year later, who published no independent work, but drew most of the excellent figures

which illustrate those of his brother, and was associate-author of some of them, died a year and a half earlier. Both were devoted Roman Catholics, and it is understood that, in giving up botany on account of broken health, they retired to a specially religious and recluse life, filled with acts of charity.

Between the years 1841 and 1865 L. R. Tulasne was a prolific author, and his work was always excellent in matter and in finish. Excepting a single essay upon embryology, the phænogamic papers and memoirs all relate to systematic botany. The most considerable of them are his classical monographs of *Podostomaceæ* and of *Monimiaceæ*. The mycologists tell us that his Fungi Hypogæi and the Selecta Fungorum Carpologia are the most important works of the age in that department. A. G.

2. *Drugs and Medicines of North America, a publication devoted to the Historical and Scientific Discussion of the Botany, Pharmacy, Chemistry and Therapeutics of the Medicinal Plants of North America, their Constituents, Products, and Sophistications.* Vol. I. Ranunculaceæ. J. U. LLOYD, Commercial History and Pharmacy. C. G. LLOYD, Botany and Botanical History. Cincinnati, 1884–85, pp. 304, imp. 8vo.—With the ninth fascicle this volume is completed, and an index, new title-page, etc., are given. It appears that, besides the very numerous figures (over one hundred), which are scattered through the letter-press, there are twenty-five full-page illustrations, chiefly figures of the plants under consideration, and very good ones too. An idea of the thoroughness and extent of the work may be had by considering that this whole volume is devoted to the plants of one order, the *Ranunculaceæ;* and "it cannot be denied that a plan so comprehensive has involved great expenses and difficulties." One reads, therefore, with a gratification not unmixed with wonder, the courageous announcement that: "We next take up the succeeding natural orders, and hope to continue until we have completed the subject."

Having already given a notice of the earlier parts of this volume, now brought to completion, we have only to state that the last two fascicles are devoted to *Cimicifuga* and to *Xanthorrhiza*. The authors will notice that we follow their orthography of the name. It is the unquestionably correct form. The only reason why it has not been altogether adopted is that the form given by L'Heritier, *Zanthorhiza*, was supposed to have been earliest in publication, and botanists are not allowed much discretion in mending faulty names. But as the origination of the name is generally attributed to Humphrey Marshall, and as he published it with the correct initial, in the same year (1785) which is borne on the title-page of that fascicle of the *Stirpes Novæ* by L'Heritier, who prints it with a wrong initial letter, no rule of priority is violated in the correction of a faulty orthography. This may be done without charging, as the authors of this volume do (in a foot-note), "that L'Heritier deliberately stole the name and antedated its publication." They have themselves antedated it, by

giving 1784 as the date of L'Heritier's publication: that fascicle of the *Stirpes Novæ* bears the date of 1785. He got the plant from the English gardens, to which it came from Bartram, and took up the name under which, doubtless, it came to him. Between a wrong and a right form of the same name, under the same date, there is no question which should be employed.

The genus being anomalous in *Ranunculaceæ*, and having a woody stem, containing plenty of berberin, our authors opine that the genus should be transferred to the Barberry family. But the floral characters would be far more incongruous there; and it would be carried away from *Hydrastis*, which has the same yellow coloring matter and also contains berberin. A. G.

3. *Leerboek der Planten-physiologie*, door HUGO DE VRIES. Amsterdam: Brinkman, 1880. pp. 300, 8vo.—This is the physiological and histological part of the *Leerboek der Plantenkunde*, i. e., the Botanical Text Book of Oudemans and the present author, with which the Netherland students are highly favored. It is out of print; but when the expected new edition appears, it would be well if some one would translate it into English. For Professor de Vries is as excellent in exposition as in research. We turn to this volume just now because the author is one of the most notable investigators of plant-movements, and was among the first to indicate the correlation of these movements with growth. If we rightly remember, he was at first inclined to regard the movements as a phenomenon of growth. But he was too good an observer to rest in that opinion, the total improbability of which must be manifest upon a survey of the whole field. For obvious reasons, visible movements would in general be manifested only in growing or freshly grown organs, and varying turgor of the protoplasm of the cells concerned, which causes the visible movements, must needs go along with growth. But when the tendril of a *Sicyos* incurves or coils promptly upon a light touch, straightens after a brief interval, and coils again upon renewed touch, and when as a result of repeated irritation, the organ becomes weak and flabby instead of rigid, one would say this is no more the result of alternate growths on the two sides than are the movements to and fro of the leaflets of *Desmodium gyrans.* As De Vries states it, while growth and turgor may be intimately associated, in very many cases there is no permanent elongation of the part, but only a temporary lengthening due simply to increase in turgor; that in others, when accompanied by growth, the latter is insufficient to account for the wide movements; and that in still other cases, where there is no recognizable growth, the movements are attributable to variations in turgor alone. He suggests, in continuation, that "the elongation which cell-walls undergo in these movements through turgor generally, may exert an influence upon intussusception by which new solid molecules are thrust in between previous existing ones in the direction in which elongation has taken place; consequently the elongation, at first caused by turgor only, may after-

ward become independent of it. The extended observations of Professor Penhallow, recorded in the three preceding numbers of this Journal, may be interpreted in accordance with these views. We should say that they do not necessitate the quite different conclusions he draws in his summary on page 189. A. G.

4. *Baillon's Dictionnaire de Botanique* we now have down to the nineteenth fascicle, and down to the latter part of the letter G, with the accustomed fullness of articles of every sort, germane to the subject, and with the usual wealth of illustrations. See for example the article *Fruit.* A. G.

5. *Baillon's Histoire des Plantes.*—After considerable delay we now have the closing part of the eighth volume, but with title-page to the parts only, none of the volume itself; and the same is to be said of the two last preceding volumes. The present part, which goes with the *Compositæ*, is a monograph of the *Campanulaceæ* (in a very extended sense), *Cucurbitaceæ*, *Loasaceæ*, *Passifloraceæ*, and *Begoniaceæ*. A. G.

6. *Plants naturalized in the southwest of France: Recherches sur les Plantes naturalisèes dans le Sud-Ouest de la France;* par JOSEPH LAMIC. An exhaustive article of 122 pages in the Annales des Sciences Naturalles de Bordeaux et du Sud-Ouest, tom. iv, 1885. —The basin of the Garonne, and especially the neighborhood of Bordeaux and Bayonne, is thought to have received a larger infusion of foreign plants, in proportion to its indigenous species than any other part of France, or even of Europe. Dr. Guillaud estimates them at about one-thirtieth of the Phænogams of the flora. M. Lamic counts them at 80 out of 2500. In this essay, after sketching the features of the region (ancient Aquitania), and defining what he means by a naturalized plant (not hesitating to include those which multiply by budding, if they are fully established), and considering the degrees, proofs, and means of naturalization, he takes up these denizens in order, and tells us what is known of the mode and time of introduction. We will note some of the North American species.

Lepidium Virginicum, L.—This was detected at Bayonne within the half century, and up to 1868 was unknown elsewhere in France. It has spread widely since the introduction of railways, and doubtless by their aid, partly through increase and continuity of its favorite habitat, *in glareosis.*

Senebiera pinnatifida, DC., or *didyma*, Pers.—This is attributed to the Southern United States, but its home is probably farther south.

Hibiscus Moscheutos, L.—The history of the identification of *H. roseus* of S. Europe with this species is given in full detail. There is no documentary evidence of its introduction into Europe where it has been known (in Italy) for 350 years. If our author were acquainted with it in its native country he would have dismissed his lingering doubts as to its North America origin.

Rhus typhina, L.—Propagates by seed and is establishing itself in southwestern France.

Robinia Pseudo-acacia, L.—Alphonse de Candolle would not admit this to be really naturalized in Europe, on the ground that it multiplied only by the root. Mr. Lamic asserts that to his knowledge, it spontaneously propagates by seeds as well.

Gaura Lindheimeri, Engelmann and Gray (by some oversight attributed to Linnæus) finds a place in this list because it was found growing wild near a railway station in the Landes. Dr. Guillaud thinks it came with American grain which had been unloaded there. This seems to us very improbable. It is more supposable that it was an accidental escape from cultivation.

Solidago Canadensis, L., *S. glabra*, Desf., *Erigeron Canadense*, *Aster Novi-Belgii*, &c., need not be remarked upon; *Boltonia glastifolia* is a recent arrival, but at some places near Bordeaux it seems to have come to stay.

Vittadinia triloba, DC.—M. Lamic says this is a native of New Zealand; he should mean New Holland. But his plant doubtless is *Erigeron mucronatum*, of Mexico, which persists in European gardens under this totally wrong name, long since corrected.

Xanthium macrocarpon, DC., which we suppose is one of the forms of *X. Canadense*, Mill., though perhaps not original to so northern a region, was known in Europe only around Montpellier in 1814; it is now largely diffused through a wide region.

Asclepias Cornuti, has recently naturalized itself in Aquitaine, where it spreads freely by its deep root-stocks. Lamic refers its home to the southern Atlantic States; we should refer it rather to the northern.

Sagittaria obtusa, Willd.—The male sex of this species has in some way been transported from N. America to the waters of the Bordeaux district, where it is spreading widely, although it never fructifies; in this respect it follows the example of *Anacharis Canadensis*, which has also occupied the waters of the whole district.

Juncus tenuis, Willd., is also a late naturalization. Lamic reckons Georgia and Carolina as its home: but its range is more largely northern.

From their omission, it would appear that *Elatine Americana* and *Ilysanthes gratioloides*, which have somehow found their way to the region of the Loire, have not reached the basin of the Garonne. A. G.

7. Professor Edward Tuckerman, one of our oldest and best botanists, and probably the most profound and trustworthy lichenologist of the day, died at Amherst, Massachusetts, on the fifteenth of March. A. G.

8. *Adaptation to an emergency in the Cicada septendecim.*—Dr. J. S. Newberry, in the School of Mines Quarterly (vol. vii, January, 1886) describes a singular case of adaptation to a new condition in the Seventeen-year locust. A surface of ground, in the outskirts of Rahway, N. J., in which the larvæ of the locust had buried themselves, as the sequel shows, was afterward built over. The cellar of one of the houses, which was without a floor

over the earth at bottom, had been kept closed and dark until about the time for the escape of the Cicadas. When opened, it was found thickly set with tubular mud-cones, 6 to 8 inches high and 1 to 1½ thick. The bottom had been dug over to a depth of a foot into red clay, when the house was made, so that it is certain there was nothing there of the kind then. At the time of the opening, the tops of the cones were closed, and on breaking them the pupæ were found inside. After the Cicadas had appeared, holes were found in the tops.

Dr. Newberry received specimens of the cones from four citizens of Rahway, who testified to the facts as to the cellar. The club-shaped cones are roughly made of pellets of the clay. Dr. Newberry observes that the Cicadas, finding the place dark, and apparently desiring to work up to daylight, made the pellets of moist clay and with them built up the tubes, as if "for the purpose of bridging over the vacancy, and thus reaching the surface." What schooling or experience could have "fitted the Cicadas for the engineering work they attempted" Dr. Newberry leaves for others to explain. An excellent figure of the club-shaped cones accompanies the paper.

9. *Bulletin of the Scientific Laboratories of Denison University.* Edited by C. L. HERRICK, Prof. Geol. and Nat. Hist. 136 pp. 8vo, with several plates, and an Appendix of Tables for the determination of minerals. Granville, Ohio.—This first Bulletin from Denison University contains the following papers, showing remarkable scientific activity at the institution: On the Evening Grosbeak, *Hesperiphona vespertina*, with a colored plate of the bird, and a plate illustrating details in the osteology, by Professor Herrick; Metamorphosis of Phyllopod Crustacea, with five well-drawn plates, by the same; Superposed buds, with one plate, by A. F. Foerste, of the university; Rotifers of America, Part I, with a description of a new genus and several new species, and four plates, by Professor Herrick; the Clinton Group of Ohio, with descriptions of new species of fossils, and two plates containing figures of nearly forty species of fossils, by A. F. Foerste. The lithographic plates of the volume were all made by Professor Herrick. The expenses of the volume were met by the contributions of friends of the university. The material is ready for another number, which they hope to meet from the proceeds of the present volume, for which the charge is $1.25.

10. *Evolution versus Involution:* a Popular Exposition of the Doctrine of true Evolution, a refutation of the Theories of Herbert Spencer and a vindication of Theism; by A. Z. REED. New York, 1885. (James Pott & Co.).—The author of this work means well; but his subject is evidently too deep and broad for him.

IV. ASTRONOMY.

1. *Uranometria Nova Oxoniensis, a photometric determination of the magnitudes of all stars visible to the naked eye from the pole to ten degrees south of the equator;* by Professor C.

PRITCHARD. 8vo. Clarendon Press. Oxford, 1885.—This volume contains the results of Professor Pritchard's measurements during several years past of the light of the stars by the use of the Wedge Photometer. This instrument is a wedge of very nearly neutral tinted glass six and a half inches long, an inch broad, and 0·145 inch thick at one end, and tapering to ·02 inch at the other. The two places in the wedge at which the light of two stars is extinguished having been observed, the distance between them is taken as a direct measure of the difference of the magnitudes of the two stars. The stars selected are those of Argelander's Uranometria Nova.

The Harvard Photometry was published when the measures for the Uranometria were about three-fourths completed, so that Professor Pritchard has been able to compare his results with Professor Pickering's in the notes.

The Royal Astronomical Society, of London, has awarded Copley medals to both Professor Pickering and to Professor Pritchard.

2. *Nebulæ in the Pleiades.*—On the 16th of November Messrs. Paul and Prosper Henry of Paris discovered a nebula close to Maia upon their photograph of the Pleiades. It had a well-marked spiral form and seemed to proceed from the star. It was about 3′ in extent. It could not be seen in their telescopes.

The nebula was, however, afterward seen by M. Struve in the newly mounted 32-inch refractor at Pulkowa. Markings of the same nebula have since been found by Professor Pickering upon a photograph taken by him at the Harvard College Observatory, Nov. 3d. These had been assumed by Professor Pickering to be due to defects in the photographic process, but the irregularities of light correspond so closely to what is described by Messieurs Henry that there can be no doubt as to their origin. The photograph also shows markings corresponding to the disputed nebula about Merope. A faint narrow streak proceeds from Electra also. No nebulous light is noticeable about Alcyone, Atlas, Pleione, or Taygeta.

3. *Relation of the Zodiacal Light to Jupiter.*—Dr. H. GEELMUYDEN, of Christiania, in a letter speaks of Professor Searle's researches upon the zodiacal light (see this vol., p. 159). He says: "If the zodiacal matter has the same position among meteoric matter in general as comets of short period among comets, it is to be expected that the fundamental plane of the zodiacal light will have some relation to Jupiter as the principal motor in deflecting the orbits, and therefore in collecting the matter. Now it is worth remarking that the most northerly point of Jupiter's orbit has the heliocentric longitude 188°, or with 60° east elongation 178° geocentric longitude; and for matter in the same plane, but nearer the Sun, the approximation to coincidence with 160° is still greater."

4. *Relation of Asteroid Orbits to those of Jupiter.*—In Mr. Searle's paper (see this vol., p. 160) it is shown that the asteroid orbits have some relation to the plane of the zodiacal light. These

orbits should have a relation to the orbit of Jupiter. For, suppose the orbits of the asteroids to be distributed in any manner whatever, provided only that they shall make small angles with the plane of Jupiter's orbit. The action of Jupiter should give to each orbit a motion of its node, and these motions of the nodes will not be the same for the different orbits. After the lapse of a considerable time the orbits will thus evidently come to be distributed somewhat symmetrically about Jupiter's orbit.

This relation is moreover easily shown to be true in fact. For if we take on the celestial sphere the poles of the 251 known asteroid orbits and compute the center of gravity of these as points of equal weight, that center of gravity is found to be only 30′·0 from the pole of Jupiter's orbit.

Regarding this center of gravity as the pole of the *mean-plane* of the asteroid orbits, we may say: that *the plane of Jupiter's orbit lies nearer to the mean-plane than does any single asteroid orbit-plane to the mean-plane.* The asteroids whose orbits have inclinations to the mean-plane less than one degree are Medusa and Euterpe, whose inclinations are 46′ and 49′.

Only one asteroid orbit-plane lies nearer to Jupiter's plane than does the mean-plane to Jupiter's plane. The asteroids whose orbits are inclined less than one degree to Jupiter's plane are Euterpe, Elsa, and Vanadis, whose inclinations are 19′, 43′, and 55′. H. A. N.

5. *Photographs of the Solar Spectrum.*—The announcement has been recently made that the photographic map of the normal Solar Spectrum, made by Professor H. A. Rowland with one of his concave gratings, is nearly complete. Seven plates on heavy albumen paper are offered for sale; each contains two strips of the Spectrum, and one of them gives three; they are three feet long and one foot wide. The region covered by these plates extends from wave length 3100 to 5790. Those interested are already aware of the unique value of these photographs. The price for the set is $10, or $12 if mounted on cloth, and for a single plate $2 and $2.25 respectively. Orders should be sent to the Publication Agency of the Johns Hopkins University, Baltimore, Md.

V. Miscellaneous Scientific Intelligence.

1. *Report of the International Polar Expedition to Point Barrow, Alaska.* 695 pp. 8vo. Washington, 1885.—This volume contains an account of the results obtained by the United States expedition to Point Barrow in 1881, 1882, and 1883. The narrative of Lieutenant Ray is brief but interesting, and is followed by a chapter by him giving an ethnographic sketch of the natives; both of these are accompanied by a number of excellent full-paged phototypes, of the northern scenery, ice phenomena and also portraits of the Eskimos. Part IV is devoted to the mammals, birds, etc. This is written by John Murdoch except the report on Mollusks, by W. H. Dall. The remainder of the volume is devoted to the subject which formed the special study of the

expedition, viz: the meteorological, magnetic and tidal observations; this record is very full and may be expected to yield important results, especially when digested in connection with the observations made by other of the International Polar Expeditions at their respective stations.

2. *Third Annual Report of the Bureau of Ethnology to the Secretary of the Smithsonian Institution*, 1881–'82, by J. W. POWELL, Director. pp. lxxiv and 606, 4to, with numerous colored and uncolored plates and other illustrations.—The third annual report of Major Powell is, like its predecessors, a valuable contribution to Ethnology. The volume contains, besides the Director's report, which forms the introduction, papers on the following subjects: On certain Maya and Mexican manuscripts, by Cyrus Thomas; on masks, labrets and certain aboriginal customs, by W. H. Dall; on Omaha Sociology, by J. Owen Dorsey; on Navajo weavers, by Dr. W. Matthews; on prehistoric textile fabrics of the United States, derived from impressions on pottery, by W. H. Holmes; also two illustrated catalogues of collections made in 1881, by W. H. Holmes, and by James Stevenson.

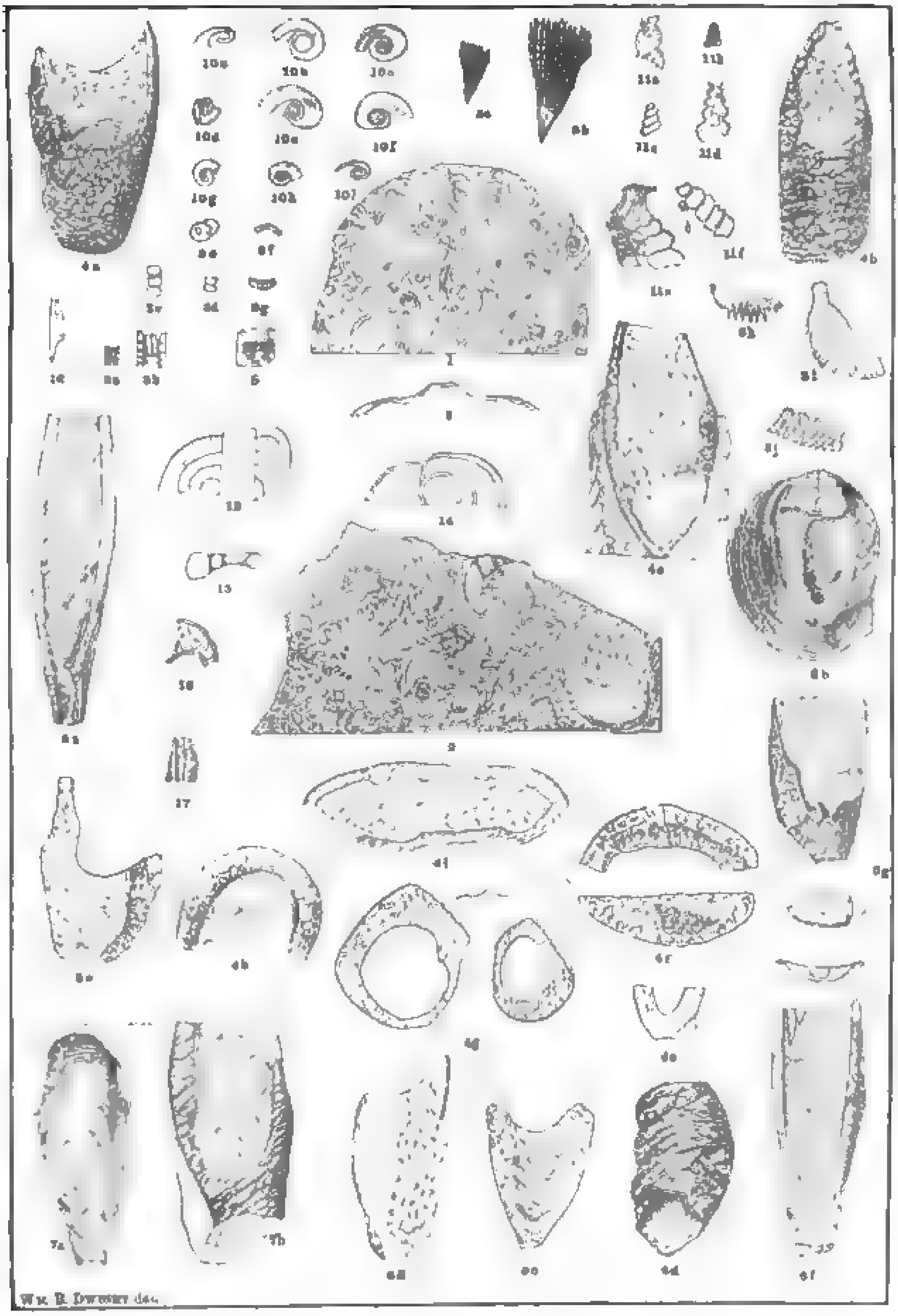
3. *Thermometer Exposure;* by HENRY A. HAZEN. 32 pp. 4to, Washington, 1885, (Professional Papers of the Signal Service, No. xviii.)—This memoir contains an extended discussion of the subject treated by the same author in an article in this Journal in 1884 (vol. xxvii, 365); it concludes with an illustrated description of the roof thermometer shelter adopted by the U. S. Signal Service.

4. *Wöhler Memorial.*—An urgent appeal is being made anew in behalf of the fund for the statue to be erected at Göttingen in commemoration of the life and work of the eminent chemist Friedrich Wöhler. This fund now amounts to about $4,000, but must be considerably increased before it will be sufficient for the end in view. The circular of the committee asks for aid, by individual subscription and influence, from all in this country interested, especially from the chemists. Prof. J. W. Mallet of the University of Virginia is Chairman, and Prof. Ira Remsen of Baltimore, Secretary and Treasurer.

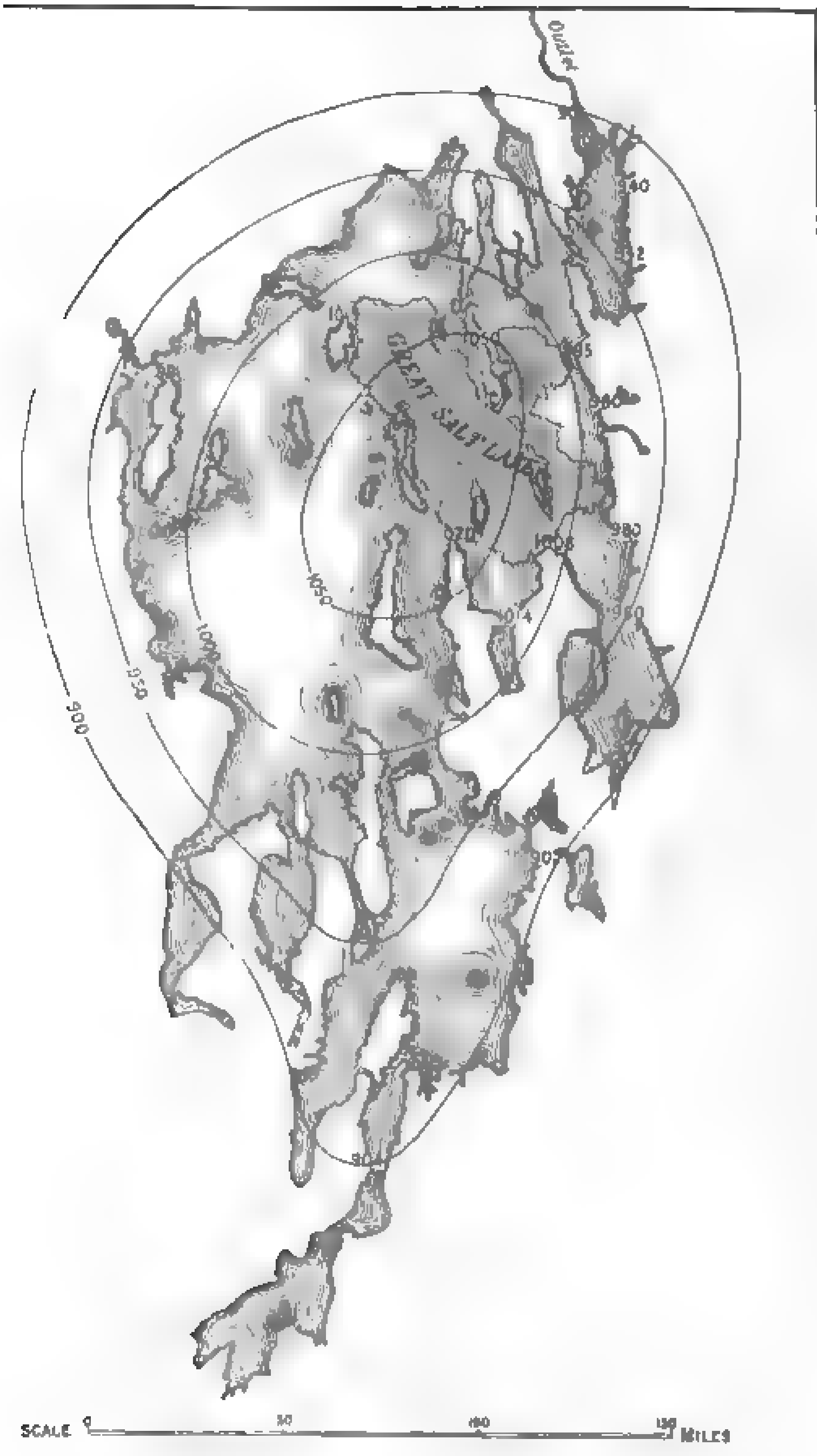
OBITUARY.

A. VON LASAULX, Professor of Mineralogy at the University of Bonn, died on the 25th of January, at the age of forty-six. He was one of the most active workers in Germany in the departments of Mineralogy and Petrography, and his early death is a severe loss to science.

HEINRICH FISCHER, Professor of Mineralogy at the University of Freiberg in Baden, died in February last. His most important contributions were in the line of microscopical mineralogy, and to the study of the various minerals included under the name jade he devoted himself most earnestly, both from the mineralogical and archæological side. His most important work was a volume of 400 pages upon "Nephrite and Jadeite" published in 1875, and a second edition in 1880.



FOSSILS FROM CANAAN, COLUMBIA CO., N. Y.



of the extinct Lake Bonneville, with hypothetic contours to illustrate the
ıent deformation of the earth's crust, by G. K. Gilbert. The horizontal
mark determinations of the height of the old shore-line above Great Salt

THE

AMERICAN JOURNAL OF SCIENCE.

[THIRD SERIES.]

ART. XXX.—*The columnar structure in the igneous rock on Orange Mountain, New Jersey;** by JOSEPH P. IDDINGS, of the U. S. Geological Survey. (With Plate IX.)

THE long ridge lying west of the City of Orange, N. J., and locally known as the Orange Mountain, is formed of beds of older Mesozoic sandstone, dipping gently to the northwest. It is capped by a layer of igneous rock variously designated as "trap," diabase or dolerite. The same rock forms the Palisades on the Hudson and occurs over large areas in Connecticut and other Eastern States. The thickness of this particular layer varies considerably, but in the vicinity of Orange it averages about 100 feet. Along the east face of the ridge it is exposed as a cliff whose lower portion is concealed under the angular fragments into which the rock readily breaks; but numerous quarries have been worked in it to obtain the material for building the excellent roads which traverse the neighboring country. These quarries, many of them of long standing, give us in section the structure of this lava sheet. In nearly all of them a more or less distinctly columnar structure is noticeable in some part of the exposure, usually the upper portion. Two localities are of special interest, because of the size and perfection of the columns in one case, and of their arrangement in converging groups in both places.

The first is John O'Rourke's quarry on Mt. Pleasant avenue, just south of Llewellyn Park. This has lately become quite

* Read before the Philosophical Society of Washington, June 6th, 1885.

renowned for its large vertical columns, which have attracted crowds of sight-seers from the immediate vicinity. While these columns are very fine examples of what is commonly met with on a smaller scale in many other localities, the chief geological interest is centered in the curving and radiating columns of smaller size into which the upper part of the mass is broken. A general view of this quarry is given in the accompanying sketch, Plate IX, made from photographs taken by the writer in May, 1884, and subsequently; it therefore exhibits some features which have been removed. At the southern end of the quarry, left end of the sketch, rise large massive columns from three to four feet thick and thirty feet high. They differ in the number of sides, having four, five or six. The faces of parting are not plane, but warped, giving a wavy form to the columns. These columns diminish in height toward the north, their breadth remaining constant, and are overlaid by long slender ones, eight or ten inches thick, which meet them at different inclinations. The main mass of these slender columns converge toward a center at the top of the cliff about 90 or 100 feet above the floor of the quarry, which is only a few feet above the beds of sandstone. Here they extend from top to bottom and slope off to the north where they again lie upon the tops of thick vertical columns like those to the south. These stretch for a hundred yards farther north and differ in height from fifteen to thirty feet, being highest near the northern end of the quarry.

Upon closer inspection it is seen that the tops of the large vertical columns taper off and curve over on one another in a direction away from the center of convergence of the overlying columns, the upper and lower columns blending along the line of junction. At the southern end of the central mass the slender columns are nearly horizontal; to the left of these are slender vertical ones joining the first along a line inclined at about 45°, along this they blend in the same manner as at the junction of the upper and lower ones. A little farther to the left, the system of slender vertical columns comes in conjunction with the larger vertical ones. The central mass of small columns is further seen to converge to more than one focus, three distinct ones lying near the face of the cliff and others having been situated a little in front of it. These slender columns are not straight except near the surface where they are in groups of vertical prisms, from which they curve gradually to an almost horizontal position.

Above the heavy columns to the north the small ones lie at various angles; those to the extreme right of the central mass are partially exposed in nearly horizontal position, their distinct forms losing themselves in a confusion of cracks, out of

which a little farther on emerge small upright columns more or less inclined. The tops of the lower massive columns bend away from the central mass just as those to the south, the junction of the two systems having been finely exposed quite recently. Where the small vertical columns connect with the lower ones, the rock is seen to be continuous from one into the other. The system of cracks alone changes and most of the upper cracks come to an end without causing a line of demarcation between the upper and lower columns.

A second and in some respects more interesting exhibition of curving and radiating columns is to be seen about a mile and a half from that just described, in the Undercliff quarry in Llewellyn Park near the north gate. The same layer of rock is here exposed in a section from 80 to 100 feet high by a cliff some 700 or 800 feet long. The lower half is divided by two quite regular sets of cracks into broad rectangular masses. Less uniform partings in other directions are occasionally noticed, but no distinct columns have been developed. The upper half, on the contrary, is divided into small columns ten or twelve inches thick, which radiate downward from foci at the surface 50 to 100 feet apart. As many as seven or eight centers can be distinctly made out along the face of the exposure. The general appearance at a distance is that of a layer of columnar rock resting upon a massive one, with a well-marked line of contact between them, but closer inspection shows that no such line of separation exists, the columns coming down unevenly upon the lower mass at all angles from vertical to horizontal, and the rock of the upper and lower portions passing uninterruptedly from one to the other. The apparent difference arises solely from the systems of cracks which divide each. The best exposure in this quarry is directly back of the stone-crusher, where the blending of the upper and lower portions can be easily seen. The same columnar structure in converging groups is exposed to the north and south of the quarry though much obscured by the soil and débris.

That the upper and lower portions of this lava sheet belong to one and the same mass of rock is shown not only by the uninterrupted continuance of the rock from the lower mass into the more nearly vertical upper columns, specially noticeable in the quarry in Llewellyn Park, and to some extent in John O'Rourke's quarry, but also by the mutual accommodation of the different sets of columns in the latter place, and the fact that along what has been supposed by some to be a plane of contact between a lower and upper flow, the columns which should then have formed last are not perpendicular to that plane, but meet it at all angles.

The lower massive columns at the southern end of John

O'Rourke's quarry are modified near their junction with the smaller ones above in exactly the same manner as the small vertical ones higher up are at their junction with the nearly horizontal columns. In each case the ends of the two sets taper off and curve in one direction, indicating that the forces developing one set of columns were affected by those developing the other set, giving rise to resultant forces which brought the columns finally into parallelism.

The columnar structure in volcanic lavas is unquestionably a cracking produced by the shrinkage of the mass upon further cooling after it has consolidated into rock, which still retains a great amount of heat. That in every case the mass is solidified before it is cracked is shown by the dividing of crystals and crystal aggregations lying in the path of the crack, which are cut across sharply, the two portions remaining firmly fixed in their respective matrices, whether these be crystalline grains or glass. In the case of volcanic glasses the columnar parting passes through the mass without in the slightest affecting the most delicate indication of flow structure, showing that the glass was rigid before it was fractured. It is also a fact of observation that the direction taken by the columns is perpendicular to the plane of cooling, often the plane of contact with another rock.

Before entering upon a discussion of the nature and development of columnar structure it will be well to consider the process of cooling and solidification of a molten lava. It is well known that a solid crust quickly covers the fluid rock after its eruption, and increases more and more gradually in thickness as the cooling advances, the fluidity of the mass beneath in like manner decreasing. Owing to the poor conductivity of rock the rate of cooling of the inner portion becomes less and less as the crust thickens, and the central portion remains at a high temperature for a very long period, as has often been observed; thus the changes in it are far more gradual and uniform than they were near the surface.

When the surface layer of a molten mass consolidates rapidly while the portion beneath is still fluid its contraction will meet with little or no resistance. The more gradual contraction of lower layers will be attended with relatively greater resistance as the fluidity of the mass beneath becomes less. The actual amount of contraction in different parts of the mass must also increase with a decrease in the rate of cooling in consequence of the greater degree of crystallization attained, for the crystalline form of a rock has a higher specific gravity than the more glassy form of the same magma and therefore occupies a smaller volume.

The resistance to contraction in the portion of the mass near

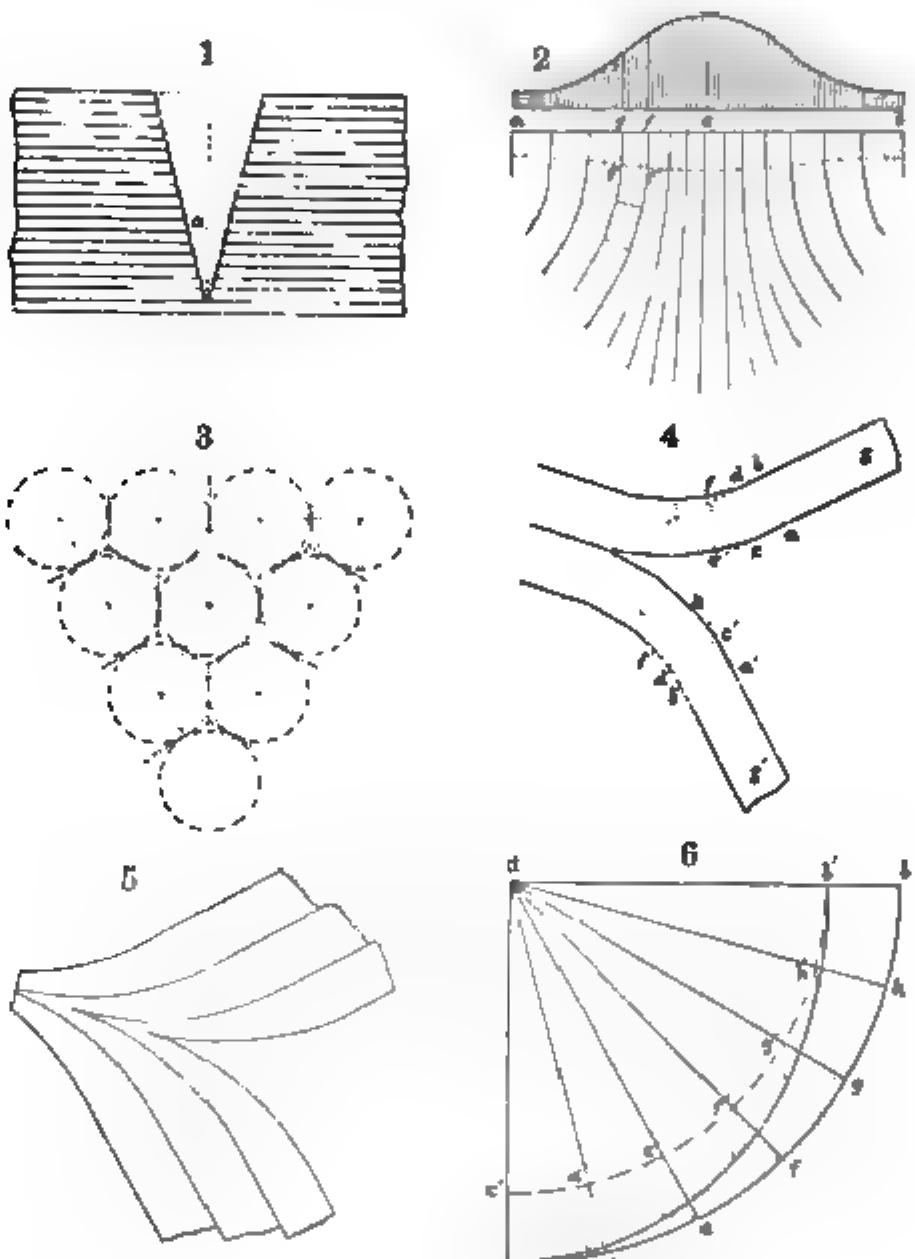
the surface, under these conditions, will be least in a direction parallel to the surface and greatest in one normal to it, and when the limit of tension is reached the resulting rupture which takes place at right angles to the direction of maximum strain, will be parallel to the surface of the mass. As the consolidation due to surface cooling proceeds inward the resistance to contraction parallel to the surface increases at a greater rate than that normal to it, a point may then be reached where resistance in the first named direction will exceed that in the second and the resulting rupture will be perpendicular to the cooling surface.

Hence it so frequently happens that the rapidly cooled, upper portion of a surface flow of lava is divided into plates approximately parallel to its surface while the more slowly cooled mass beneath is cracked more or less vertically. For the same reason also the quickly cooled sides of an intrusive mass are split into plates by cracks parallel to the contact surface, the cracks being closest together nearest the surface, where the lateral resistance to contraction has been least. These cases of tabular parting, however, must not be confounded with the general tabular parting of many lava flows which arises from inherent lamination due to layers of different texture or consistency, producing planes of weakness through the mass.

Columnar structure then is found in that part of a lava flow which has consolidated and contracted slowly under the influence of surface cooling, and the laws governing its development may be reached by considering the origin and progress of a crack caused by the shrinkage of a homogeneous mass through surface cooling. Starting with a plane surface over which forces producing contraction are acting uniformly, the contraction produced on the surface of the mass in a given time will be greater than that produced at some depth within the mass, and will decrease gradually inward. As the contraction progresses the limit of tension in the direction of the surface will be reached before that in the direction of depth causing a rupture across the direction of the surface, and as the limit of tension for the layer next below is reached it will rupture in the same direction as the surface layer did, and so on. The direction of the crack will be at right angles to that of greatest contraction, or normal to the line of maximum strain. The condition of the mass at the moment the limit of tension along the surface is reached may be graphically represented as in fig. 1, the contraction being a maximum in the top layer and diminishing successively in each layer beneath to that with the initial expansion; the distance of this layer from the surface being taken as unity the maximum contraction at the

moment of rupture will be equal to twice the tangent of a, then 2 tan α represents the limit of tension and will be constant for any given substance.

As the conductivity of a cooling body is not directly proportional to the degree of radiation from its surface the difference between the contraction of successive layers of a rapidly cooling mass will be greater than between those of one cooling less rapidly, and what may be styled the angle of contraction will be greater in the former case than in the latter. If a certain rate of cooling causes a single rupture in a given extent of



mass, represented in fig. 1, then a greater rate of cooling which would produce in the same extent of mass a contraction represented by a greater angle, β, will cause as many ruptures as the ratio $\frac{\tan \beta}{\tan \alpha}$.

If the forces producing contraction are unequally distributed

over the surface *ab*, fig. 2, being a maximum at *c*, the maximum strain at the beginning will be in the direction of the surface and the cracks will start normal to it, but their progress inward will no longer be uniform. At the end of a given time the limit of tension reached by a greater force, at *f*, will be farther from the surface than that reached by a less force, at *g*, and the line of maximum strain in this portion of the mass will be *g′f′*, to which the crack of parting will be normal. At the end of another given time the direction of the crack will be again changed, and the same action taking place in other parts of the mass will result in a system of diverging and curving cracks.

If the surface from which uniform cooling takes place is not plane but warped it is evident that the cracks normal to it will start in various directions through the mass.

So far we have considered the shrinkage in one plane only, that is in a plane at right angles to the cooling surface. But in a homogeneous mass the contractile force which produces cracks at certain distances will exert itself equally in all directions over a surface uniformly subjected to the cooling forces, and will at the instant of rupture act toward centers whose distance apart is dependent on the rate of cooling. If the mass is perfectly homogeneous the centers of contraction will be disposed over the surface with the greatest uniformity possible, that is, they will be equidistant throughout, fig. 3, and the resultant fractures will be in a system of hexagons; the inward progress of these divides the mass into prisms. If from any irregularity in the composition or petrographic structure of a rock the contractile force acts unequally in different directions. The form of the polygons will be less regular. Those most commonly found in rocks are quite irregular, adjacent prisms having four, five and six sides of unequal size.

The mutual influence of the forces producing different prisms as they approach each other is readily understood from the following: take the case of two columns *s*, *s′*, fig. 4, approaching one another, and suppose the progress of the maximum strain to have reached *ab*, *a′b′*, the forces producing contraction acting through *a* and *a′* will meet and react on each other before those acting through *b* and *b′*, so that the points of maximum strain at the end of a given time will have advanced farther along the lines through *a* and *a′* than through *b* and *b′*. The lines of greatest strain will then be *cd* and *c′d′* and the cracks normal to them will take the direction *ce* and *c′e′*. This reaction will continue till they become parallel.

If there were but two columns forming at equal rates they would curve symmetrically and continue in parallel directions and of constant width, but if one column progresses more

rapidly than the other they will no longer curve to the same extent and the slower one will curve more than the faster one. Instead of two single columns there are always two groups approaching one another, fig. 5, and these prevent the continuation of the columns beyond the curve, pinching them out and causing them to taper off as already observed in the quarry described.

The difference in the systems of cracks of the lower and upper portions of this lava sheet may then be accounted for by a difference in the rate of cooling from the bottom and top surfaces. The more frequent fractures arising from the more rapid cooling; the two systems proceeding from their initial planes until they blend in one another within the mass. If for any reason the cooling from one surface should take place irregularly and from any point proceed more rapidly than from others, it is evident that there would result a set of curving columns diverging from this point as a focus. The curving and diverging of the upper sets of columns in this locality then may be ascribed to differences in the rates of cooling from the upper surface, which might be brought about in a variety of ways. What were the most likely ones in this instance it is difficult to say, since erosion has carried away the top of the layer at this place and left us in doubt as to its original condition.

There remains to be considered the subsequent contraction exerted in all directions through the prisms into which the mass has been divided, for the effect of surface cooling having been expended in producing the prismatic cracks, the subsequent contraction results from a still more gradual cooling of each of these portions with little reference to the source of cooling. The uniform contraction of a homogeneous body acts equally in every direction through it, and its effect corresponds to the equal shortening of the radii of a sphere of such a body. If from a uniform resistance cracking or parting occurs it will take the form of concentric spherical shells. If for any reason the uniform resistance to the contracting force be counteracted by some other force acting in a particular direction the parting will no longer be spherical but ellipsoidal, as will be seen from fig. 6, where *abc* represents a section through the sphere along the radii of which contraction takes place. A uniform resistance in the direction of the radii represented by *cc'*, *dd'*, etc., will produce a parting parallel to the arc of the circle *c'd'e'*, etc. If, however, the resistance in a direction parallel to the line *ac* be neutralized by some force, the resistance along the different radii will be diminished by the amount of the component parallel to *ac* in each case, and the resulting fracture will be parallel to the ellipse *cb'*, the relative tendency to fracture also being indicated by the area *bcb'*.

Such a parting is well developed in the large columns in John O'Rourke's quarry, the major axis of the ellipsoid being vertical, as it should be if the weight of the superincumbent mass counteracted any resistance to contraction in a vertical direction. The shells formed are often quite thin, being one or two inches in width. This system of cracks is subsequent to the columnar parting, each group of ellipsoidal sunderings being confined to a single column, and not extending into adjacent ones. The lower half of most of these spheroidal groups appears to have been better developed than the upper half, but this may result from the secondary action of frost which would be greatest on the cracks retaining most moisture, as those curved upwards naturally would. Occasionally the upper set of cracks are as well marked as the lower and adjoin the lower set of a spheroidal group above. Undoubtedly the spheroidal sundering in this instance has resulted from the contraction of a cooling mass of rock, but differs from the columnar parting in that the latter is the result of progressive cooling from the surface of a mass inward, while the former is produced by a contraction acting equally in all directions through a mass.

The cup-shaped jointing of columns so well developed in some localities is probably a form of spheroidal sundering brought out by a resistance to contraction along the length of the columns and may curve in either direction as the result of particular conditions, the minor axis of the ellipsoid lying in the direction of maximum resistance.

The wavy form of the columns large and small suggests irregularities in the mass which disturbed the uniform advance of the lines of maximum strain and caused them to deviate from parallelism.

The superficial banding of the large vertical columns by nearly horizontal notches or grooves, which produce bands three or four inches wide, frequently ends squarely in a way which somewhat resembles layers of bricks, as suggested by Professor George H. Cook, in his annual report on the geology of New Jersey for 1884, where he describes the columnar structure in John O'Rourke's quarry. This banding, however, generally continues some distance without interruption, is not always horizontal and sometimes curves abruptly, appearing more like rude chiseling. The same structure is produced on columns of dried starch, it is wholly superficial and seems to be simply a modification of the plane of the crack. A cause for its development has not yet suggested itself.

The question of the origin and nature of columnar structure in lavas and other substances has been discussed by G. Poulett Scrope in his work on "Volcanos" (2d edition, London, 1872), who by a somewhat different course of reasoning arrived at essentially the same conclusions as those reached in the present paper.

Robert Mallet, in a paper "On the Origin and Mechanism of Production of the Prismatic (or Columnar) Structure of Basalt," read Jan. 21, 1875, and printed in abstract in the "Proceedings of the Royal Society of London, 1875," also showed that the cracking of a shrinking mass which is cooling from the surface is quite sufficient to account for all the phenomena of columnar structure. He referred the radiation and curving of columns wholly to influences arising from the contour of the surface of the cooling mass, not taking into consideration the effect of different rates of cooling at the surface, which must often vary greatly. He explained the cause of cup-shaped joints in a manner similar to the one here suggested, except that it is not general enough to account for the actual occurrences, since it requires all the cups to bow in the direction in which the columns advanced during their growth.

Professor T. G. Bonney, in an article "On Columnar, Fissile and Spheroidal Structure," read Feb. 23d, 1876, and printed in the Quart. Journ. of Geol. Soc., vol. xxxii, p. 140, considers the cup-shaped joint a special case of spheroidal parting, and adopts Scrope's and Mallet's views on columnar structure; he, however, considers fissile or tabular parting as an extreme form of spheroidal, for, as he points out, a plane surface is the same as that of a sphere whose center is at an infinite distance, which leads him to conclude that surface cooling of itself is sufficient to produce tabular parting, in contradiction to the conclusions already adopted that it produces prismatic cracking. This in a measure illustrates the fallacy of explaining certain geological structures and forms by a course of mathematical reasoning, simply because the ultimate forms so derived are similar to the geological forms observed, though the latter were not produced under the conditions imposed by the course of mathematical reasoning, but may have resulted in many cases from wholly different or exactly opposite causes.

As the rock from the quarries just described presents certain petrographic features which distinguish it from most of the similar igneous rocks in this part of the country, and in a measure accord with its lithological structure, a brief notice of them is here given. Generally the microstructure of these rocks is holocrystalline, formed of lath-shaped, basic feldspar, irregular crystals and grains of augite, grains of iron-oxide and considerable green serpentine or chlorite, which is disseminated through the mass and is evidently the alteration product of a fourth primary constituent. It is probably the drying of this serpentine or chlorite which after a time gives a greenish color to the surface of the rock, which is dark bluish-black when broken. The rock from John O'Rourke's quarry is unusually fine grained and dark colored, and parts of it show little if any change on exposed surfaces. Specimens collected from the

large columns and from different levels of the central mass of small columns show almost no macroscopic differences, but under the microscope a decided variation is noticeable. In most of the thin sections the rock appears but slightly decomposed; it is not holocrystalline but contains a variable amount of glass base, which is more or less globulitic with augite microlites having opaque grains attached, besides larger aggregations of magnetite grains. There is a comparatively small amount of light green serpentine in patches, the larger of which still contain fragments of olivine at their centers, the primary mineral from which the serpentine has been derived. In some places the glass base has been colored green though still isotropic, while in others it has been devitrified through decomposing agents.

The rock with the least glass and coarsest grain of crystallization is from the large columns about six feet above the floor of the quarry; that at the same level but from the central mass of small columns shows nearly the same size of crystals as in the first but more glass base. The rock forming columns a foot thick and fifteen feet above the second specimen has somewhat smaller feldspar crystals and more glass base, in places brown and globulitic with fernlike groups of magnetite crystals. Midway up the cliff the rock shows still more globulitic and microlitic glass; and that from ten feet below the present upper surface has smaller crystals and rather more glass base.

The variations from bottom to top of the lava sheet are slight but distinctly noticeable, and indicate that the cooling which caused the consolidation of the mass was more rapid at the top than at the bottom, which corresponds to the subsequent conditions deemed necessary to produce the different systems of columnar cracking.

This rock is in every way identical with many medium-grained basalts, which have been poured forth as surface flows in recent times, and should be called basalt, and its coarser grained forms dolerite, as Professor E. S. Dana has called similar rocks in the Connecticut Valley. ("Trap Rocks of the Connecticut Valley," E. S. Dana, Proceedings of the American Association for the Advancement of Science, 23d meeting, 1884.)

The occurrence of the rock in question as a surface flow is rendered highly probable by its glassy nature and the disposition of the columns, which resembles that of many lava sheets in Western America where the irregular cooling may be directly traced to irregularities of surface or to local porosity or cavities within the mass. Another source of irregular cooling may be found in the loss of heat by convection in the atmosphere, but more especially in water where the flow has been subaqueous.

ART. XXXI.—*Larval Theory of the Origin of Tissue*, by A. HYATT.*

I HAVE endeavored in the essay of which this is an abstract to demonstrate a phyletic connection between Protozoa and Metazoa, and also to show that the tissue cells of the latter are similar to asexual larvæ and are related by their modes of development to the Protozoa just as larval forms among the Metazoa themselves are related to the ancestral adults of the different groups to which they belong. This is indicated by the fact that the tissue cells exhibit highly concentrated or accelerated modes of development according to a universal law of biogenesis, which has now been found in almost all groups of animals. Thus in forms, which stand at the extreme limits of groups in point of specialization of structure, or have unusually protected young, or pathological forms with stimulated development, in fact, any forms in which stimulative causes have acted upon the young so as to bring about an earlier development at the expense of the normal rate of growth, there may be observed an abbreviation of the usual series of structural characters, which appear in the young of normal forms of the same group. The observations of many authors, notably Cope, Hæckel, Balfour, Weissmann, Packard and Wurtemburger have conclusively proved that examples of abbreviated or concentrated development are the results of a constant tendency in all organisms to acquire characters in adults or later stages of larvæ and then to inherit these at earlier and earlier stages in successive descendants; thus finally crowding the younger stages until some ancient characters are skipped, sometimes leaving no record of the derivation of the organism and at others only a highly abbreviated record in the earlier stages.

No bushy colonies of zoöns or cells are built up in the Metazoa, representing the incompletely divided colonies of the adults of Protozoa, except in cases of incomplete segmentation of the ovum. These forms are skipped and the complex colonies, which arise by fission, consist of zoons divided by distinct walls. The cycle of transformations is not only shortened by this omission, but the origin of the reproducductive bodies is carried back into the earlier stages in many forms, and the rapidity of the processes of complete fission due to concentration produces masses of tissue and membranes

* This article is an abstract of a paper with same title published in Proc. Bost. Soc. Nat. Hist., vol. xxiii, 1884, p. 45–163, but has in addition the suggestion that Volvox and Eudorina are true intermediate forms entitled to be called Mesozoa, or Blastrea.

in place of loosely connected colonies as among Protozoa.*

The many disconnected, wandering cells with their independent organization, and functions favor this conclusion, and the sight of these and of ova in the mesenchyme of sponges and the evidence of their functions here and elsewhere in the animal kingdom is sufficient to bring a candid mind to open confession of the existence of exact parallelism between them and the single, individualized Amœba.

These and other morphological facts have led, so far as we know, only to comparisons between the ordinary tissue cells and the adults of the amœbæ, and it has been assumed that these cells are the equivalents of the adult amœbæ.

Morphologically this seems to be true, but it does not account for the physiological differences between the Protozoon and the cell. The ontology of the cell, its production of tissue, and the reduction of the cycle of transformations cannot be explained unless we attribute to it a concentrated energy in reproduction and a tendency to form closely united and complex associations much greater than that of the Protozoon.

Thus a single Metazoon is a colony of infinite complexity in which the two primitive colonies, ectoderm and endoderm, have produced by growth and agamic fission all the anatomical systems, and their various organs and smaller parts.

Studies of reproduction show that the succession of events among Protozoa was first growth, then fission, then the union or concrescence of divided zoons and an exchange of their complementary parts; evidently all of these influences bear upon the tissue cell and influence its reproduction. Nevertheless two cells do not combine previous to reproduction by fission, and whatever the effect of the original impregnation may be, we are obliged, therefore, to regard a young cell as a modified agamic larva-like form or zoon, when compared with the full grown Amœba. If descent from Amœbæ, through Flagellata and Ciliata is assumed then the task of proving young cells to be immature forms becomes easier. In this case they are obviously forms, which like the ova of many Metazoa have retained their ancient, amœboidal characteristics while losing their later acquired flagellate and ciliate similarities.

We cannot use the words embryo and larva, which belong to the ovum after impregnation, and we, therefore, propose to designate the cell an autotemnon,† in contrast with the embryo, which is more specialized. The least specialized tissue cells of

* The net work of protoplasm connecting tissue cells is disregarded in order to show the massive nature of tissues and at the same time state their characteristic cellular composition.

† From Αὐτος, self, and τέμνω, to divide.

the mesenchyme differ less from the individualized agamic zoons of the Protozoa, while the spermatocysts, as more highly specialized, encysted male zoons, retain the cycle of agamic transformations derived from their male Protozoonal prototypes, and are intermediate to the encysted female zoon or ovum.

The spermatocyst, in other words, is not dependent upon impregnation for its development, and has necessarily retained more of the characteristic, successive transformations of the primitive agamic forms than the ovum. This last has become dependent upon impregnation. The tendency to earlier and earlier impregnation in successive generations, and the correlative concentration of autotemnic stages, as shown by the fission of the nucleus and exclusion of the polar globules, has finally established the ovum as a more highly specialized form of cell.

The conditions of fission in the cyst of a Protozoon, and in the ovum and spermatocyst are similar as long as the zoons or cells are all similarly confined, but when they burst the envelope and become free, the surrounding conditions differ and they correspondingly diverge.

The early encystment of the ovum, the non production of the colonial form by incomplete fission, the dependence of the feminonucleus upon impregnation, and the great rapidity and extensive character of the changes by which the diploblastic parenchymula and triploblastic gastrula are built up, all show the excessive concentration of development which has taken place, when any blastula is compared with the corresponding forms among the Volvocinæ. There is also a distinction between the mode of development of the Volvocinæ, and the lower Protozoa which has, we think, great significance. They have prolonged gestation and this can be compared with the similar prolongation of the corresponding period in the early inception of the ovum in the Metazoa.

They are, however, necessarily only single cells. The whole process of segmentation occurs under conditions which effectually protect the earlier stages in the higher Protozoa, and in all the Metazoa, but, as might have been anticipated, the more specialized Metazoon elaborates at once and within limits of this early egg stage a fully formed colony, the blastula, whereas the highest and most specialized of Protozoa get no farther than the production of single ova and spermatocysts* or the earliest stages of segmentation during the same period.

* For results of protection in producing concentration of development see Genesis of Planorbis at Steinheim, Mem. Bost. Soc. Nat. Hist., I Anniv., 1830-1880; Fossil Ceph., Mus. Comp. Zool., Proc. Amer. Assoc. Adv. Sci., vol. xxxii, p. 32, also Balfour's Comp. Embryol.

The adult condition of Eudorina or Volvox in other words is a permanent morphological equivalent of the blastula stage in the ovum of a Metazoon, and a spermatocyst holds a similar relation to the encysted reproductive stage at the terminus of life in an Amœba. It, however, occurs at the beginning of life in this specialized male cell among Metazoa. The spermatozoa also which are produced by fission of the nucleus resemble the young of the Amœbinæ and many other Protozoa in form, but have through earlier inheritance of characteristics acquired the functional power of the adult male Protozoon, and are, therefore, as compared with Protozoa, to be estimated morphologically and functionally as microgonids with highly concentrated development. In no other way can we account for the premature exhibition of power shown by these forms in seeking out the egg, and forcing their way into the vitellus. Ultimate union with the female nucleus of the ovum by passage through the vitellus is quite distinct. It has appeared to us to be like concrescence in low forms an exhibition of mutual attraction which indicates affinity, and like all sexual processes a vital attraction of greater intensity than mere fusion by growth and in no way attributable to accident. The habit may have sprung from the habit of concrescence, just as we can only imagine all sexual processes as springing originally from concrescence through its transformation into a habit preparatory to reproduction by division as among Myxomycetes. Crinkowski considers concrescence to have originated from the habit of feeding and the results of concrescence, reproduction by fission, as a function due to the same causes and having the same results as assimilation (Archiv. Mik. Anat., vol. ix).

There is a gradation in the stages of development of the ectoderm, endoderm and mesenchyme in the sponges which show they have retained the ancestral protozoonal characteristics in some cells more than in others. Thus the ectodermic cells in all the Porifera become permanently transformed into flat epithelial cells losing their feeding organs, the collars and flagella, whereas the cells of the endoderm in some forms, such as the Ascones, probably never lose these organs at all, and in others lose them only transiently at certain stages or only locally on the walls of the archenteron in the intervals between the diverticula (primitive ampullæ).*

In the mesenchyme of sponges the cells have been subjected to fewer changes and they preserve their ancient amœboidal forms unaltered. The comparatively great change in the evolution of the group probably took place after the transfer of

* Von Lendenfeld (Austral. Sponges, vol. ix, pl. 4, Proc. Linn. Soc. N. S. Wales, pl. 64–65), describes *Homoderma sycandra* as having these cells equally distributed all over the endoderm as well as in the single ampullæ.

the principal seat of assimilation from the endoderm to the mesenchyme. This transfer possibly occurred during the genesis of Sycones, and other higher forms.

The researches of Saville Kent among Protozoa have shown that the collar and flagellum are feeding organs and we must imagine them as having a similar meaning in the internal cavity of Ascones, the lowest forms of sponges.

When we consider the whole series of transformation of the ovum it becomes apparent, that it is at first an autotemnon having the amœba stage well and clearly developed. The ovum develops parallel with the spermatocyst through the period of division of the nucleus into two parts, the masculonucleus and the feminonucleus. We have tried, in common with some other authors, to show, that the masculonucleus is probably thrown off in the polar globules during a process of agamic division of the nucleus and that these are the homologues of the masculonuclei excluded from the spermatocyst after having been transformed into spermatozoa.

The remarkable essays of Professor Ed. Van Beneden on the bisexual nature of the nucleus are the only embryological writings which produce the proofs of this hypothesis in illustrated form. This author (Fecund. Maturat. de L'œuf, Archiv. de Biol., tom. vi, 1883) advances precisely similar views to those of Dr. Minot, and shows the phenomena of fecundation and the double composition of the maritonucleus in a series of remarkably clear illustrations. Van Beneden claims to be the discoverer of the bisexual composition of the nucleus of the ovum and refers to his paper of December, 1875 (Bull. Acad. de Belg., vol. xl, 1875) as containing the first statement of his discovery. Though not pretending to forestall the judgment of those better qualified to decide the merits of these claims, we find that Professor Van Beneden was the first to announce the basal facts of the bisexual theory, but that he did not give all of the essential conditions of the phenomena of conjugation between the male and female parts of the nuclei in his first paper. This author in the work just cited (p. 700) suggests that the peripheral pronucleus is probably partially formed of spermatic substance, that the central pronucleus is female and that the segmentation nucleus is a compound body resulting from the union of these two, and is, therefore, probably bisexual. This statement includes all the basal facts of the genoblastic theory, with, however, two important exceptions. It omits any notice of complementary behavior or functions of the useless parts of nuclei in both the spermatocyst and ovum. This essential condition of the conjugation of the nuclei does not seem to have been elaborated by Van Beneden until 1883, long after the appearance of Dr. Minot's paper.

Dr. Minot (Proc. Bost. Nat. Hist., vol. xix, p. 170) proposed to name the original bisexual nucleus "genoblast," the female part, "arsenoblast," and the male, "thelyblast," and these terms have precedence of those we have advanced, or of those proposed by Van Beneden, but we have preferred to use names which retain the word nucleus, as more expressive of the true relations of derivative nuclei.

If this is true the occurrence of this process of excluding the masculonuclei in the ovum during the agamic stage exhibits an earlier inheritance of a characteristic which in the Protozoa occurs only after and as a result of impregnation, except possibly in some of the more specialized Flagellata and Ciliata, where the existence of spermatocysts and spermatozooids leads one to anticipate a corresponding differentiation. The female zoon certainly appears to be in reality an ovum, and to develop like one into a blastula as pointed out by Butschli.

This view includes some results worthy of attention. The concrescence of Protozoons, as in cases cited by Drysdale and Dallenger, and in some plants where the whole contents of one pair of cells, or more than one pair of cells, are mingled together, is asexual conjugation, but not sexual conjugation. The latter occurs only by the exchange of differentiated parts of nuclei, or between the larva-like spermatozoa and the complementary part of the nucleus in the ovum. Thus such forms as Eudorina and Volvox might be called, on account of their morphology, Blastrea, and could, because of their mode of reproduction and the existence of but one layer in the body wall, be appropriately designated as true Mesozoa.

With regard to the meaning of the early stages of the ovum, we come nearer to Butschli (Morph. Jahrb., 1884), than any other author, and regard his placula theory as opening a way far more promising than any so far proposed. This author, however, voluntarily rejected the aid of the sponges in his arguments, under the erroneous impression that they were Protozoa and holds an essentially distinct idea of what the placula is. The embryo of the Calcispongian is, according to our opinion, a single layered placula or a Monoplacula, and directly comparable with the undifferentiated flat colonies of Protozoa which are more primitive than the Blastula form and represent the simplest condition of an autotemnic colony of Protozoa, like Desmarella of Saville Kent, though not possessed of cilia at this stage and therefore more nearly perhaps representing a mass of amœboid forms.

The formation of the apical or esoteric cells of the upper layer from the cells of the Monoplacula transforms this stage into a diploplacula, the older or basal cells becoming our exoteric cells. True ectoblastic and endoblastic cells first appeared

during the gastrula stage, and are supposed to be identical with the differentiated cells often found in the blastula and placula. But in both of these last they are in distinct association and correlate with distinct forms and should be considered as simply exoteric and esoteric cells. They are not true ecto- or endo-blasts until they assume the relations of an external and internal layer as in the gastrula stage. The absence of the placula in many forms may be explained as due to concentration of development. The protected conditions under which the ovum originates makes the constant retention of the placula unnecessary and favors the earlier inheritance of the morula, or mulberry stage; in fact, any quickening of the processes of growth would bring about this change and the morula stage is only a heaping up of cells into a more massive colonial growth. The rounded globular forms of the morula would thus replace the placula earlier in the life of the embryo and occasion its disappearance in more highly specialized forms, as in the Carneospongia.

This theory is apparently very similar to that of Butschli so far as relates to the origin of the placula, but differs in making the morula an important stage of the evolution of forms and in insisting upon the placula as primitively monoplaculate and only secondarily diploplaculate. Butschli's placula is in reality a later stage, a specialized flattened stage of an embryo Metazoon.

Butschli points out the resemblances of the embryo of Cucullanus, Rhabdonema, and Lumbricus to the placula, and the apparently primitive mode of forming the segmentation cavity in the latter by the separation of the two layers is also given in detail by him. Butschli also consider the Trichoplax adhærens of Schultze, as a living illustration of a full grown, primitive, placulate form.

We ought to find primitive stages in the embryos of a primitive type and this is eminently the case with Porifera. We should anticipate the opposite with a higher type like the worms or any metameric animal and this appears to be borne out by what Butschli brings forward in support of his theory.

In Cucullanus the earliest stages are rounded, and we cannot agree with Butschli, that the flattened form which follows this is a primitive placula, or diploplacula. The primitive placula is a single layer which becomes double or diploplaculate and in both stages must precede the morula, and cannot succeed this stage. It will be seen by our remarks above that the esoteric and exoteric differentiations would have occurred normally before the morula stage in the placula of Cucullanus, or else in fusion with it and therefore the double layered placula of Butschli would be necessarily a flattened morula in which

the two layers had already been formed. The relations of the planula stage in Cucullanus and Lumbricus to the gastrula also indicate, that it is simply a modification of the morula stage, and not comparable with the earlier premorula stages of the embryo. The formation of the gastrula in Cucullanus is a beautiful example of extra growth of the octoblast, as has been pointed out by Balfour, and in this and in Lumbricus a true embolic gastrula is formed by this process which is not more primitive than that which occurs in the Ctenophoræ or Tubulariæ. The gastrula in other words is formed according to a highly concentrated secondary mode of development, and not by primitive or simple processes. We should, therefore, even while adopting Butschli's theory, decline to accept his typical examples as true illustrations of the theory, and hold rigidly to the law of succession in the stages of the embryo for justification of this position.

We cannot give a better illustration of what we mean by a monoplaculate embryo than Hatschek's Amphioxus in the four-celled stage,* nor of our diploplacula than the same in the eight-celled stage, when the cells of the esoteric layer are first differentiated, which occurs even before the two poles of the embryo become closed and long previous to the stage when the blastula is formed.

Immediately after the diploplaculate stage the ovum of Porifera and Amphioxus, as well as some other types, presents a stage during which it is a tube open at both ends. The hereditary significance of this stage indicates a tubular ancestral form through which water would freely circulate, and this strengthens our position with regard to the meaning of the aula of the blastula.

The central cavity of the blastula stage, the so-called Protogaster of Hæckel, connects with the exterior by a blastulapore, the "Protostoma" of Hæckel, which is normally closed later in the growth, but remains open for long periods in some sponges, as may be observed in the figures of *Sycandra raphanus*, and in the larva of siliceous sponges, as in the embryos of Halichondria and Tethya. The assumption, that such a primitive cavity necessarily originated as a gastric cavity, seems improbable.

The prototype of this cavity, the aula, must have first appeared as a central hollow in a moving colonial form of Protozoa, simply as a mechanical necessity of the habits and mode of growth, and might have been useful as a float, but was probably not a gastric cavity, but on the contrary similar in every way to the internal cavity of the Volvox blastula. The additional advantage of the possession of such a hollow in en-

* Arbeit. d. Zool. Inst. d. Univ. Wien, Claus, iv, hft. I, pl. I.

abling the cells to use both sides instead of one, and to perform the functions of respiration, ingestion and excretion more completely is obvious. The growing of the cells of the ovum into a hollow sphere, the blastula with its blastulapore opening externally, is described by Butschli as essentially similar to the growth of the adult floating spherical colonies of Volvox and Eudorina from a single zoon by fission. This author (Bronn's Thierreichs, Protozoa, pl. 45) gives a series of figures illustrating the development of the asexual zoons of Volvox which fully substantiate his comparisons, and, together with Carter's, show that the closest comparisons may be made between the early stages of the ovum and those of all forms of Volvox, which is an open blastula like that of some Porifera before it leaves the parent colony and becomes free.

All of these comparisons seem to be much opposed to Butschli's supposition that the primitive cavity of the blastula originated from a separation of two layers rather than as a stage of development from one primitive layer and the formation of an aula.

In order to account for the differentiation of the esoteric cells we have imagined them, as necessarily by position feeding cells in the ancestors of the diploplaculate stage. In the free morula and closed blastula the same cells or their more modified descendants would tend to retain similar functions. The differentiation of the poles would occur in this blastula form according to the same law, as is observed in the higher animals, and the tendency already initiated of the zoons of one pole to become exclusively feeding zoons would be increased by more frequent contact with food, and by being constantly occupied in the act of ingestion. The differentiation of the cells having been thus established and kept up by a continuance of similar habits, and the aula correlatively developed, we should have a free moving form with the cells at one pole feeding cells, and at the other probably more efficient as respiratory cells. These last need not be necessarily inefficient as feeding zoons, but might have remained quite capable of this office, as well, also, as that of developing flagella for moving the body, and in fact resembling in aspect and structure what we actually find in the amphiblastula of some sponges. We here claim for the exoteric or ectoblast cells, that their possession of collars and flagella implies the existence of powers of ingestion. We think the negative evidence, adduced by Metschnikoff and others, with regard to these cells in the embryos of sponges is entirely inadequate to prove anything except the fact that they have not seen them actually feeding, and do not weigh against the observed functions of the collars and flagelli of the Flagellata, especially the positive and convincing proofs brought forward by Saville Kent.

The Parenchymula is a recently discovered stage of the embryo immediately succeeding the closed blastula. The esoteric cells differentiated during preceding stages have been found, by several authors, to quit the exterior where they originated and wander into the interior where they presumably give rise to the endoblastic cells subsequently found there.

A differentiated colony, like the amphiblastula with the cells at one end becoming better fitted to take in food, could be transformed into a parenchymula by the migration of differentiated feeding cells into the interior and the Parenchymula could thus have been transformed into a true gastrula. There are no living forms, so far as we know, with which the Parenchymula can be compared, and its probable meaning has already been indicated by other writers, especially by Metschnikoff, namely, that it implies a radical form in which the mesenchyme has arisen as a primitive mass by delamination.

The inwandering of the esoteric cells of the parenchymula might be reasonably assumed as in part due to pressure. This appears to be a primitive mode of forming the endoderm as stated by Schmidt and Metschnikoff, and therefore, we should have to consider pressure as simply a possible cause aiding the tendency to inwandering, as it appears in the habits of these cells of the parenchymula. It is possible that this tendency was derived from ancestors in which a primitive invagination appeared as a later characteristic of the development, due to excess of growth in peripheral parts and that the same conditions of growth and pressure would continue to be present in the similar parts of the young of descendent forms as long as the surroundings and habits were sufficiently similar and did not interfere with hereditary tendencies. Thus we should have to regard the habit of inwandering of the esoteric cells as giving rise to the primitive endoblast, and this last as a permanent stage preceding the transient gastrula due to invagination. The continued action of the same cause as gave rise to the tendency to inwandering, namely, the pressure occasioned by the rapid multiplication of external cells by growth and the action of heredity would secure this result.

The fact that the esoteric hemisphere is an excessive peripheral outgrowth of cells in the amphiblastula is in perfect accord with the successive stages in the development of pits, and minor invaginations of the ectoderm. These are universally in their primitive stages peripheral outgrowths of the outer membranes, which form primitive hollows and then these cups become hereditary invaginations in the embryos of decendent forms. The formation of stomodea and other ectodermic invaginations can thus be accounted for as in every way parallel to formation of the gastrula, and due to similar causes.

The invagination of the endoblast in the ordinary form of the gastrula is immediately accompanied and caused, according to Whitman, by pressure arising from the unequal growth of the hemispheres. The pressure on the endoblast after invagination is shown by the forms of the cells, which become elongated along the middle part of the cup, as in the well known case of Amphioxus described by Kowalevsky, and many examples by other authors. The growth and excess of pressure is also evinced in the elongation of the planula and the tendency of the at first broad blastopore to close up to a narrow opening by growth of the ectoblast. The usually columnar aspect of the ectoblastic cells of the planula, their longest axes being radial, or at right angles to the direction of the pressure, is also favorable to this theory. These cells may be attenuated in Porifera at this stage (Barrois, Épong. de la Manche) so as to assume an almost linear aspect under low powers of the microscope. We feel obliged to join those authors who regard the planula stage as an abbreviated form of the gastrula possibly directly derived from the epibolic gastrula. The succession of the stages is first a peripheral outgrowth increasing continually the diameter of the amphiblastula, then invagination, then peripheral growth of the ectoblast, followed by elongation of the planula and contraction or obliteration of the blastopore. Heredity in these cases seems to be subordinate to growth, but this we think is due to the necessarily identical action of these inseparable forces. Heredity and growth are also necessary in order to account for cases of epibolic gastrulæ, as well as for the existence of the planula. The action of heredity in the planula is obvious, but in the transitional epibolic gastrula the obvious mechanical action of growth still interferes with the clear perception of the influence of heredity. The growth of the ectoblast cells is so rapid in the last named, that the endoblast cells become inclosed as in the Ctenophoræ, and the gastrula is formed by a process much shorter than is usual in embryos of the embolic type.

In a planula we can see very clearly that some other force in addition to growth has been at work, and that, whether we adopt Lankester's hypothesis or some other, we are equally obliged to call in the aid of heredity in order to explain the hidden steps by which the embolic gastrula has been transformed into this concentrated form of development through the epibolic gastrula as an intermediate stage.

Keller (Anat. und Entwickel. einiger Spong. d. Mittelmeers, Basel, Georg, 1876), has given the fullest illustrated account of what we have, in common with Metschnikoff and Schultze, called the transient gastrula of the Calcispongiæ. A recent perusal of this interesting paper has suggested that there is

probably no better field for the study of the effects of pressure upon cells than in these cases of transient invagination. It is possible that the invagination stage may be traceable directly to excess of growth in the ciliated cells and their subsequent evagination as outgrowths to the reversal of this process, and at any rate the field is a very promising one in this direction.

We have also noted in our original essay the probability, that the medullary fold was primitively a stomodeal invagination due to extra growth, and we are able to quote in this connection an observation of Dr. Hatschek's in addition to those of Kollmann and Gardiner.

Dr. Hatschek (Arb. Zool. Inst. Wien, vol. iv, 1881, pp. 45–48) attributes the origin of the primitive segments and other changes of form in the embryro of Amphioxus to the growth and energy of cells. He explains the origin of the medullary plate by differentiations in the cells caused by the extra-growth of the neighboring cells of the ectoderm, and attributes the rise of the ends and final inclosure of the neural canal to lateral outgrowths due to the same cause.*

The general presence of the different forms of the gastrula, including the planula, indicates, as we have tried to show above, that Hæckel was right in supposing that these stages indicated common ancestors for the whole animal kingdom. To this we have also joined the Architroch of Lankester, imagining in common with this author, a very ancient origin for the circles of cilia around the blastopore of the primitive gastrula-like ancestors of the Invertebrata.

The history of the structural transitions through which the layers of the body pass in their subsequent history sustain the view that the Porifera are the lowest type of Metazoa. The endoderm and ectoderm reach a highly differentiated stage and appear as flat epithelial membranes, but the middle layer remains a mesenchyme containing, as stated by all authors, the reproductive bodies of both sexes. The appearance of spermatozoa and ova indifferently in the same animal shows, that entire separation of the sexes does not take place so far as now known, among Porifera. It is not yet established, that cross fertilization occurs in any form, though there is as yet no grounds for the positive assertion that it does not occur. The history of the early stages exhibits a larval form in which the interior is solid for a certain period and the mesenchyme plays a much more important role than in any other branch of the animal kingdom, as might be anticipated from the adult condi-

* See also His, "Unsere Körperform," 1875, pp. 60–61, 83 and 178, who has essentially the same idea of the relations of growth of cells and development of organs.

tion and importance of this layer in the morphology of the group.

We have also tried to show that the general morphology and development indicated the gradual evolution of series of forms from a type similar to Ascones but without a skeleton, which we have considered directly comparable, as stated by Hæckel, with the gastrula. During this evolution the mesenchyme became more and more important, and as a result of its thickening the habit of budding was more or less suppressed so that the higher types must be considered as individuals with a highly plastic form, liable to excessive outgrowths, but not as branching Metazoons. The archenteron also remains persistent throughout life, gives rise to simple diverticula, or, in forms with thick mesenchyme, diverticula themselves form branching tubes.

The fact that no internal column or body cavity is formed, in spite of the opportunity offered by the increasing thickness of the mesenchyme is very significant. It is not yet established that the mesenchyme does receive some additions in course of its growth from the endoderm and ectoderm, but so far as the histology is now understood it is doubtful.

In other words the Porifera are intermediate with regard to structural composition between primitive larval individuals, like the free larvæ of all colonial types, and the differentiated colonies which arise from such primitive individuals after they become attached, as in the Hydrozoa. They contain all the elements necessary for the formation of complicated colonies, but in consequence of the less differentiation of the mesenchyme their primitive individuality is maintained and the processes of budding take place internally and externally without perfect correlation. That is, the exterior has outgrowths and so has the archenteron, but these are not strictly coincident and produce true buds only in forms with thin mesenchyme.

The evidence in favor of the opinion that the diverticula or Ampullæ are strictly homologous with the archenteric diverticula of all other animals is very strong. The young have no diverticula until the ampullinula is formed and this correlates with the absence of these organs in the adults of the lowest type, Ascones. These facts among sponges seem to be in accord with the history and development of the diverticula among Hydrozoa and Actinozoa, and leads to the conclusion that in all of these three types the diverticula are homoplastic organs, and not found in the lowest forms of these groups or in the early stages of development of the normal forms.

The considerations we have presented above have, therefore, a direct application to the results of the work done of late years by Semper, Dohrn and others in tracing the origin of the vertebrata to some worm-like type. The whole of this evi-

dence hangs necessarily upon the probability that the somites of the embryo of Amphioxus imply descent from a segmented animal; whereas, if we are correct, exactly the opposite view may be considered as the more probable; and the very close comparisons made by Semper between what he considers homogenous organs and parts in Vertebrata and Vermes can only be considered as evidence of the production of homoplastic effects by means of similar modes of growth and the similar habits of elongated and necessarily bilateral animals.

We have objected to the theory that the Vertebrata may be considered as descended from a Cœlenterate ancestor because the actinostome probably arose independently and very late in the phylogenetic history of the Hydrozoa, and undoubtedly arose independently in the Porifera. A stomodeum as it appears in the ascula stage or in a sycon or ascon may be a single opening not due to invagination, merely an enlarged pore or outlet. The cloaca of the more specialized sponges is first an outgrowth of the peripheral parts which becomes inheritable and causes the appearance of the ectoderm as a lining layer extending to an indefinite depth into the interior. A stomodeum, also, does not exist in most of the Hydrozoa except in the primitive shape of an outgrowth, the hypostome, which is the homologue of the internal actinostome of the Actinozoa. These facts and the late stage at which it arises in the Actinozoa, during the gulinula stage, shows us that so far as these types are concerned it is an independent and homoplastic organ in all of them.

There are no exact comparisons between the embryos of Ascidia and Amphioxus and those of the Invertebrata which seem to include any stages later than the planula. Those that have been traced between the mesoblastic somites indicate homoplastic organs, and seem to have no phylogenetic meaning so far as the whole of the Vertebrata are concerned. The distinct modes of development of the anterior invaginations of the Vertebrata show that they had a different origin from the anterior tube of the actinostome, and cannot be considered homogenous with that organ in the Cœlenterata. The medullary invagination is at first a stomodeum arising as a funnel around the blastopore, and then spreads forward in the shape of two folds, which subsequently form a tube, and it is probable that the notochordal tube, and the lateral differentiations of the archenteron may have had a similar homoplastic simplicity of structure.

The development in Ascidia of the notochordal cells and muscle cells from the walls of the archenteron invite the suggestion that no true diverticula exist in this type. That the lateral muscles might have arisen as entirely disconnected and

more primitive structural elements than the cœlomata is shown by Kowalevsky's work on Cassiopea already quoted (Soc. Friends of Nat. Hist., etc., Moscow, pl. II, f. 10–13). In this Hydrozoon, portions of the archenteric walls grow out and become directly converted into muscles, but no cœlom is formed.

The notochord may have primitively originated as a tube, but connections with the hypophysis seems to be a necessary condition of this theory, and though this is highly probable, it is not proven. The homoplastic origin of the notochord, when explained in this way, agrees with the subsequent origin of segmentation in the vertebræ as suggested by Cope. These facts and agreements in theory render it highly probable, that the whole phenomena of segmentation as shown in the distribution of the muscles themselves, the appendages, and internal organs including even the primitive somites may have arisen independently in the Vertebrata in response to the simple mechanical requirements of motion in elongated bodies. Herbert Spencer in a treatise much neglected by naturalists (Prin. Biol., Am. Ed., 1871, vol. ii, p. 199), has clearly shown that the origin of the notochord and of segmentation of the vertebræ and muscles may be attributed to muscular strains, and our speculations though entirely independent cannot lay claim to any original merit.

Our results are similar to those of Hæckel so far as they distinctly point to the gastrula and planula as the earliest stages which have a general genetic meaning for the Metazoa and show that these indicate a stock form for the whole of the Metazoa. The clear distinctions between the type-larval stages in different branches of the animal kingdom and the fact, that the type larval stages make their appearance invariably after the planula or gastrula, and never under any conditions break this natural succession, give strong support to this opinion.

It is possibly premature to say that no one type can be claimed to have descended from any other, but the Porifera, Hydrozoa, Actinozoa and Vertebrata appear to us entirely independent of each other. It is also very suggestive that two so closely allied groups as the Actinozoa and Hydrozoa, can be considered as homoplastic types and that many examples have been brought forward by the author and Professor Cope* among Cephalopoda and Vertebrata, where smaller and more closely allied groups, orders, families and genera show the same phenomena and are plainly homoplastic with reference to the origin of many important characteristics of structure. These results sustain the opinion that homogenous characteristics are

* Cope, who first pointed out these relations in the same sense as Lankester used the terms "homologous" for homoplastic and "heterologous" for homogenous.

frequently so similar to purely homoplastic characteristics, that it is not safe to consider any characteristics occurring in distinct groups as homogenous until their phylogenesis has been traced or their comparative embryology is fully understood.

The hypothesis of the common, but independent origin of types is also supported by all collateral evidences. The results of palæontologic research have carried back the origin of distinct types farther and farther every year. It is now established, that there was an excessively sudden appearance of vast numbers of forms in the Cambrian or perhaps earlier as claimed by Professor Marcou and others.

We have applied this specific statement as a generalization to the history of smaller groups of fossils in several branches of the animal kingdom and in many formations, and have found that the sudden appearance of the smaller groups occurs according to the same law.

There is an obvious plasticity in the animals which first make their appearance in any unoccupied field, or at the beginning of any new formation, which reminds one of the plastic nature, of the most generalized type of Metazoa, the existing Porifera. The generalized types, which always occur first in time, exhibit like sponges exceptional capacity for adaptation to the most varied requirements of the surroundings, and all of the conditions of the new period or habitat by the rapid development of numbers of suitable and more highly specialized forms, species and genera.

The whole picture as presented by morphology, embryology and palæontology favors the hypothesis we have previously advanced in other papers, namely, that the early geologic history of animal life, like the early stages of development in the embryo was a more highly concentrated and accelerated process in evolution than that which occurred at any subsequent period of the earth's history.

The history of the Porifera and higher Protozoa suggests also that the evolution of the Metazoa may have occurred more rapidly than we can now calculate. One of the great errors of the present day is the assumption that such changes and transitions occurred slowly and gradually; and it is evident that this assumption is based almost wholly upon investigation of the more highly specialized animals in which the capacity for change may be reasonably considered as very much less than in their more generalized and embryonic ancestral forms.

ART. XXXII.—*Cretaceous Metamorphic Rocks of California*; by GEORGE F. BECKER.

IN the course of an investigation of the quicksilver deposits of California, which will form the subject of a monograph of the U. S. Geological Survey, the crystalline and serpentinoid metamorphic rocks of the Coast Ranges have been subjected to an elaborate examination. As the complete report can hardly be distributed in less than a year from the present time, it appears expedient to print an abstract of the results obtained, but all detailed proof of the statements made will be deferred until the final publication.

The chemical analyses connected with the examination have all been performed by Dr. W. H. Melville, the field work was performed by Mr. H. W. Turner and myself together, and the microscopical examinations were made jointly by Mr. Waldemar Lindgren and myself.

The field studies were made at very numerous points from above Clear Lake to the region of New Idria, thus partially covering a belt of the Coast Ranges of about 230 miles in length. Throughout the whole region there is structural and lithological evidence that the sedimentary rocks are underlain by granite of very uniform character, and, wherever they are inconsiderably modified, the slides prepared from them show that they are directly or indirectly derived from granite, or, in other words, that they are arcose. Of this material of known origin a portion has been highly altered. The alteration-processes to which it has been subjected are identical from one end of the region to the other, and innumerable transitions are presented. It is difficult to estimate the area occupied by the metamorphic rocks of the Coast Ranges, because the occurrences are of very irregular shape. A moderate estimate of the exposures between Clear Lake and New Idria, which consist of holocrystalline metamorphic rocks, sandstone in which recrystallization has made considerable progress, phthanites and serpentine, is 3,000 square miles. Large areas covered by late Cretaceous and Tertiary strata are also known to be underlain by metamorphics, and this series is known to extend far to the north and to the south of the limits indicated without substantial change in character. The study is thus not one of mere recrystallization, but of regional metamorphism of irregular intensity and therefore the better fitted for investigation. The age of the altered beds is known from direct paleontological evidence at a number of localities to be Neocomian, or very nearly of that period, and there is no evidence that any considerable quantity of older rocks is included within the area. The

epoch of the metamorphism is also clearly proved to be within the earlier portion of the Cretaceous period and probably about the close of the Neocomian.* The most interesting alteration processes to which the sandstones have been subjected are closely similar to those which characterize metamorphic areas elsewhere, consisting chiefly in the metasomatic recrystallization of the sediments to holocrystalline feldspathic rocks carrying ferromagnesian silicates, and in the formation of vast quantities of serpentine. It is also clear on structural and chemical grounds that solutions rising from the underlying shattered granite coöperated in the metamorphism.

Thus the origin of the sedimentary rocks, their mineralogical character in an unaltered state, their age, the approximate epoch at which they were metamorphosed, and the general character of the conditions of metamorphism, are all known, while the exposures illustrating the comparatively few more important problems are numberless. I am not aware that metamorphism has ever been studied under conditions so favorable for elucidation. It is unnecessary to say that the material is not exhausted by a single investigation and that much must remain to be done, especially from a chemical standpoint, in the present state of knowledge. It is believed, however, that a solid basis has been obtained for future inquiry, and that the results reached are sufficiently definite to form an important aid in the study of metamorphic areas elsewhere, which present less favorable opportunities for complete investigation.†

Excepting the light cream-colored schists of Miocene age which occupy a narrow strip along the coast of California from the neighborhood of Santa Cruz southward, the rocks of the Coast Ranges where unaltered are mainly sandstones of Cretaceous and Tertiary age. Sandstones often occur here in practically uninterrupted series of beds many thousands of feet in thickness. The mechanical condition of the accumulation of such vast quantities of sand forms a problem which has not been solved for this area, nor, so far as I am aware, for any similar area elsewhere. The unaltered sandstones of the Coast

* Notes on the stratigraphy of California by G. F. Becker, Bull. U. S. Geol. Survey No. 19. Notes on the Mesozoic and Cenozoic Paleontology of California by C. A. White, Bull. U. S. Geol. Survey No. 15.

† As it is nearly or quite impossible for any investigator to free himself wholly from preconceptions, it may not be superfluous to state that in beginning the study of the quicksilver belt I entertained no opinions as to the character or origin of the crystalline and serpentinoid rocks. I was prepared to find the former either eruptive or unaltered crystalline precipitates and entertained no prejudice against regarding the serpentine either as an original deposit or as a product of the alteration of olivine. Though I have reached different conclusions as to the occurrences of this area, I do not in the least doubt that every mineral has been produced somewhere in nature by every possible method.

ranges are very much alike whatever their age, the Téjon (Eocene) beds however are of a much lighter color than the Chico (late Cretaceous) or the Miocene rocks. The Chico again is usually more indurated than the Miocene. While the Knoxville (Neocomian) sandstones, where unaltered, closely resemble those of later periods, no case is known in which unaltered Knoxville beds are not intimately associated with greatly disturbed and metamorphosed rocks of the same age, so that there is no difficulty in discrimination when once it is established, that the epoch of violent upheaval and metamorphism followed soon after the close of the Knoxville. This fact I have already proved.*

Field study showed that the Coast Ranges are probably everywhere underlain by granite. The microscopic examinations have given this inference unexpectedly strong confirmation, for though on structural grounds it appears certain that a portion of the later sandstones were formed at the expense of earlier arenaceous beds, they all exhibit unmistakable evidence of granitic origin. They are thus so similar that they may be discussed together lithologically. The microscope shows that the main constituents are quartz fragments with abundant fluid inclusions, and in other respects entirely resembling the quartzes of the underlying granite, orthoclase and the same plagioclases found in the granite. Biotite in foils deformed by the pressure of the adjoining grains is not infrequent, and decomposition products traceable to this mineral are common. Clastic grains of hornblende exactly like that in the granite are tolerably common. Apatite, titanite, zircon, tourmaline, rutile and epidote, also occur. The only clastic constituent not directly referable to the granite consists of black scales, which are sparsely disseminated in some localities, and which resemble in some cases fragments of carbonaceous shale, while in others they suggest plant remains. The proportion of quartz in the sandstones is as a matter of course greater than in the granite. The grains are commonly rounded like ordinary beach sand, but are sometimes extremely sharp. The cement is largely calcite. The sandstones are subject to the ordinary decomposition known as weathering, by which the ferromagnesian silicates are in part converted to chlorite and in part to a ferruginous cement.

Sharply defined limits cannot be drawn between the various metamorphosed rocks of the Coast Ranges; they pass over into one another by degrees. For purposes of description, however, it is desirable to consider certain types as distinct. The divisions which appear to satisfy best both their field occurrence and their microscopical character are as follows: *Par-*

* Bull. U. S. Geol. Survey, No. 19.

tially metamorphosed sandstones in which, although a process of recrystallization has begun, the clastic structure as seen under the microscope is not obliterated but is often more or less obscured. This class will be referred to hereafter for the sake of brevity as altered sandstones. *Granular metamorphics* in which metasomatic recrystallization of sandstones has transformed the mass into a holocrystalline aggregate which, in its most complex development, consists of augite, amphibole, feldspar, zoisite, quartz and accessory minerals. This class cannot be sharply separated from the first or from the next following. By the suppression of one or more constituents, groups are formed under this class, such as metamorphic diabase, metamorphic diorite, amphibolite, etc. The third class embraces the *glaucophane schists* derived from certain shales much as the granular metamorphics are produced from sandstone. These schists almost invariably carry muscovite, quartz, zoisite and other minerals. The *phthanites* are a series of more or less calcareous schistose rocks which have been subjected to a process of silicification resulting in chert-like masses, which retain schistoid structure and are intersected by innumerable quartz veins. They usually carry more or less zoisite. Finally the *serpentines* which have resulted in part from the direct action of solutions on sandstones and in part from alteration of the granular metamorphics. They cannot be rigidly divided from the rocks from which they are derived, since many of these contain some serpentine; but there is also a very large amount of tolerably pure serpentine in the region under discussion.

A considerable number of minerals have been generated in these rocks by metasomatic processes and weathering. These are biotite, muscovite, augite, hornblende, glaucophane, labradorite, andesine (probably), oligoclase, albite, orthoclase, quartz, zoisite, rutile, ilmenite, titanite, apatite, garnet, nacrite, chlorite, epidote, serpentine and chromite. Talc is known to occur in the Coast Ranges but does not happen to be represented in the collections for this investigation. A careful search has been made in the slides for other minerals as rhombic pyroxene, andalusite, dipyre, prehnite, allanite and zeolites, but without success. Zeolites have been found macroscopically in vugs, but not as rock constituents. The most interesting and in some respects the most important mineral found is zoisite, which has been repeatedly analyzed and tested. It corresponds completely to that found by Mr. A. Cathrein in the European saussurites.*

* Dr. T. S. Hunt was, I believe, the first to show that some saussurites were largely or wholly composed of saussurite (this Journal, vol. xxvii, 1859, p. 336). Mr. Cathrein showed that many of them are mixtures of zoisite and feldspar (Groth's Zeitschrift für Krys. u. Min., vol. vii, 1883, p. 234). Since the composition of saussurite is known, it does not appear desirable to retain this designation for the mixture.

Though not among the most readily recognizable minerals, it can be distinguished with tolerable ease by its physical and optical properties. Some of its important characteristics are as follows: rather strong refraction, tint under the microscope colorless to faint yellowish green, in the latter case slightly pleochroitic, colors of interference bluish gray to a dull yellow, this tint being sometimes pale and sometimes strong but rarely or never bright. It occurs in granular aggregates and in prisms; the latter are usually jointed, occasionally more than twenty times. The prisms are generally fluted in the direction of the main axis. Cross-sections are square or show a single corner truncated. The axes of elasticity are as nearly as can be observed strictly parallel to the main crystallographic axis and to the pinacoidal faces. The angle of the optical axes is large and their plane is parallel to one of the pinacoidal faces. Glaucophane was first recognized in rocks from California, so far as I know, by M. Michel-Lévy in 1878.* It appears to be connected with ordinary hornblende by transitions. No special comments are requisite on any of the other minerals excepting serpentine, which will be discussed below.

All the more important processes of metasomatic recrystallization can be traced in the altered sandstones, rocks the clastic origin of which could not be doubted for a moment. In many cases one of the first stages in the process is the resolution of the clastic grains into crystalline aggregates from which new minerals are again built up. Augite and hornblende have been observed forming in this manner. The newly-formed ferro-magnesian silicate crystals are often composed of groups of microlites not quite united and yet possessing a common crystallographic outline. The sharp edges of these minerals, their structure and the relation to the still traceable clastic fragments, all forbid the supposition that they are themselves transported fragmental material. Feldspars form in the same way, and in some cases it can be shown that a single newly-formed feldspar with sharp crystallographic outlines occupies the position of several of the original clastic grains. The feldspars also crystallize along tiny veins in the slides. A frequent occurrence is the resolution of quartz grains into plagioclase microlites. The reaction begins on the surface of the quartz grains and produces a fringe of twinned feldspar microlites in positions approximately normal to the surface of the residual kernel. The microlites do not merely abut against the kernel, but penetrate it for a sensible distance like closely set pins in a cushion. The newly-formed feldspars in the altered sandstones are in part elongated microlites, in other cases they are granular. Zoisite is present in nearly all the

* Fourth Annual Report State Mineralogist of California, p. 182.

altered sandstones. It forms in the aggregates which result from the clastic grains and its microlites sometimes pierce quartz grains from the outside. It is abundant in the granular as well as in the prismatic form. A sandstone from New Almaden has been subjected to somewhat irregular alteration. Although the rock as a whole is both macroscopically and microscopically a fragmental one, there are fields in the slide which have the mineralogical and structural character of an eruptive diabase. These areas do not represent inclusions but pass gradually over into others in which the clastic character is unquestionable.

It is only necessary to suppose the processes indicated above carried further to obtain a product in which the clastic character of the rocks would cease to be evident. The altered sandstones thus form under the microscope as they do in the field transitions from the clastic series to the holocrystalline rocks.

The granular metamorphic rocks of the Coast Ranges are separable under the microscope into several groups, but this is not practicable by unaided vision; indeed there are many cases in which specimens which appear to the naked eye to be not greatly altered sandstones prove under the microscope to be holocrystalline rocks with none of the microstructure of a sandstone. The most important class of the granular rocks is a metamorphic diabase in which the pyroxene sometimes assumes the form of diallage. None of this rock has been found in place which carries olivine, but in one district occur rounded pebbles of an olivinitic gabbro, which is probably of metamorphic origin. This is the only olivinitic rock excepting basalt met with in this region. The metamorphic diabase in a large proportion of cases carries much zoisite. It also frequently contains hornblende. Metamorphic diorites are also not infrequent, and in some cases the quantity of hornblende so greatly exceeds that of the other constituents that the rock deserves the name of amphibolite. Glaucophane occurs in both the diabasic and the dioritic rocks. The quantity of zoisite in these rocks is very variable, and in some cases is so great that with feldspar it forms almost the entire mass. The schistose metamorphics, not including phthanites, are all characterized by the presence of glaucophane. In every case but one, zoisite is associated with the glaucophane in this group, and either muscovite or biotite is usually present.

The phthanites or silicified shales form a very distinct group readily distinguishable from the granular metamorphics. They usually are green or brown in color and intersected by innumerable quartz veins. They contain microscopic organic remains, and imbedded in the quartz veins or projecting from their walls are often numerous zoisite crystals. All of these

rocks are best represented by detailed descriptions of special examples for which there is no space here.

Serpentine in a comparatively pure state occurs throughout the quicksilver belt in irregular areas. As nearly as can be estimated these areas amount to somewhat over 1,000 square miles between Clear Lake and New Idria. Serpentine is also one of the mineral constituents of many of the altered sandstones and of the granular metamorphic rocks. In order that there might be no mistake as to the identification of this mineral in its various relations, quantitative analyses and qualitative tests have been made of many occurrences. The optical properties have been studied in the specimens analyzed and microchemical tests have been applied to confirm optical determinations. The result obtained is that the serpentine of the massive occurrences and that of the partially serpentinized sandstones and granular metamorphics is the same. It is a biaxial variety, often just perceptibly dichroitic and rarely shows differences of tint as great as those characteristic of chlorite. It might be called antigorite if it seemed needful to separate the biaxial serpentines. Bastitic developments are common, but these masses do not appear to be pseudomorphic or to differ, except in regularity of structure, from the ordinary forms. Chrysotile and marmolite, which are not infrequent, seem also mere structural modifications. The net structure so usual, though not invariable, in serpentine formed from olivine has nowhere been detected. Where any considerable quantity of serpentine is present it usually shows the grate-structure first studied in the Alpine serpentines by von Drasche and since by others in the Grecian and Swedish occurrences.

No considerable portion of the serpentine of the Coast Ranges has resulted from the decomposition of olivine. Only pebbles of a single olivine gabbro have been found and these contain a mere trace of serpentine, while the origin of the serpentine has been traced in a great number of cases to rocks containing no olivine. Field observations show most conclusively that the great mass of the serpentine of this area is derived from the sandstones either immediately or through an intermediate granular metamorphic rock. This is evident both from the larger features of structure and from the details of separate croppings. Highly inclined strata strike into serpentine areas in such a manner as wholly to preclude the supposition that the serpentine is an older mass, and one side of an anticlinal fold is serpentinized while the other is unaltered and carries excellent fossils. These relations are particularly clear at Knoxville and at Mt. Diablo. There are also clear cases of transition from sandstone to serpentine. In the conversion of more or less metamorphosed sandstone masses to serpentine as

seen in the field, the transformation begins along the cracks, working toward the centers of the included fragments. Where the process is incomplete the structure produced is entirely analogous to that of decomposing olivines as seen under the microscope. Sometimes, but not often, the serpentine assumes a radial form, the fibers being normal to the surface of the nucleus. Prof. Whitney observed such a case at New Idria, and I found a very beautiful one at Knoxville. The serpentinoid rocks usually show evidence of very violent dynamical action.

Under the microscope it can be shown, as I think, beyond a question, that all of the principal components of the sandstones and granular metamorphic rocks are subject to serpentinization. After the investigations of von Drasche, Hussak, Eichstädt, Weigand and others, it will surprise no one to learn that augite and hornblende are converted to serpentine.* The decomposition begins along the surfaces and cracks exactly as in the case of chloritization and uralitization. Though vom Rath, Bischof and others have shown that the conversion of feldspar to serpentine is probable, I am not aware that any definite proof of this change has been published. In the Coast ranges it seems beyond a doubt. The feldspars are corroded externally, cracks are widened irregularly and filled with serpentine, and in some cases elongated teeth of serpentine may be seen biting into the clear feldspathic mass. It is impossible to explain these and many similar occurrences except on the supposition that a reaction between some fluid and the feldspars has yielded serpentine.

That quartz is sometimes converted into talc is a well known fact. In the altered sandstones of the Coast Ranges it is converted into serpentine. The proof is similar to that of the transformation of other minerals. In one very beautiful instance a clastic quartz grain of characteristic form, full of fluid inclusions, and containing an imbedded apatite microlite has been attacked from the outside. The original outline is preserved, but the outer layer of the fragment is now entirely occupied by felted fibers of serpentine and in addition long, slender, green needles pierce into the quartz toward its center. That there might be no doubt as to the character of this occurrence, the slide was uncovered and a second entirely similar, but less beautiful instance was chemically tested.

* Without entering here upon any review of the serpentine controversy, it may be noted that although the hypothesis that serpentine is substantially a result of the alteration of olivine seems to have been based chiefly upon the investigations of Professors Sandberger and Tschermak, published in 1866–7, Sandberger recognized the formation of serpentine from the hornblendic rocks and diabases, and Tschermak describes the conversion of enstatite to serpentine. Dr. Hunt also admits the derivation of serpentine from enstatite in some cases.

The direct conversion of quartz to serpentine is a very general and very important process in the Coast Ranges.

Apatite is also converted to serpentine in the rocks under discussion,* while mica and garnet occur under conditions which suggest but do not prove their transformation to serpentine. Pseudomorphs of serpentine after these minerals are known to occur elsewhere. Zoisite is probably but not certainly serpentinized.

The lithological and mineralogical results reached for the unaltered and metamorphosed rocks of the Coast Ranges having been briefly sketched, a few notes on the general geological and chemico-physical relations of the process of transformation remain to be stated. In the present state of opinion it is not superfluous to insist upon the derivative character of the holocrystalline metamorphic rocks and the serpentine of the quicksilver belt. It appears that at least one mineral of nearly universal distribution in the granular and the schistose rocks, and in the phthanites is especially significant in this respect, and that a sound argument may be based upon its presence independently of other evidence. Zoisite is not known to occur as an original component of eruptive rocks nor, considering that it is essentially a hydrous mineral, is it easy to conceive that it should so occur. That it may be met with in such rocks, like epidote, as a product of decomposition is not improbable, but when .it is found imbedded in clear continuous minerals evidently formed in place and showing no decomposition. as is the case in these rocks, there can hardly be a question that these minerals have been formed at a comparatively low temperature, probably below the boiling point and certainly below a red heat. The proof of the metamorphic character of the rocks is wholly independent of zoisite, however, and would be abundantly convincing if zoisite were a common constituent of lavas.

The depth at which the rocks now exposed were buried at the epoch of metamorphism, soon after the close of the Neocomian, was probably a moderate one, perhaps 2,000 or 3,000 feet. At a sufficient pressure rocks appear to be moulded by dynamical action rather than crushed, and Dr. Lehmann has shown that under such conditions even crystals may be bent. In the Coast Ranges no such phenomenon has been observed. On the contrary, the amount of fracturing is really astonishing.

Both the Coast Ranges and the Gold Belt are underlain by granite, which probably also forms the bed rock in the great valley of California. It is impossible to conceive of any force which should have produced intense lateral compression in the sedimentary rocks overlying the granite without disturbing the

* Prof. J. D. Dana observed pseudomorphs of serpentine after apatite, this Journal, vol. viii, 1874, p. 371.

latter. The granite as well as the strata above it must therefore have been disturbed and laterally compressed at the close of the Neocomian. Many thousand square miles of exposures of rock shattered until the average size of the unbroken lumps does not exceed that of an egg indicate the amount of energy converted into heat in this process. Before the upheaval, the sandstones and even the granite must have contained water which was warmed by this heat and, since the action was compressive, interstitial space must have been reduced, tending to force the solutions formed to the surface along the lines of fracture. Under these conditions chemical transformations were inevitable and it is as nearly as possible certain that these would not be confined to a mere molecular rearrangement of the constituents of the sedimentary rocks, but that the granite also would be involved.

Without entering into any discussion of the chemical processes here, it is sufficient to state that the indications of field study are that the solutions were at first very warm and basic and that the earliest stage of the process of metamorphism was the conversion of the sandstones and some shales to holocrystalline rocks carrying augite and amphibole. Serpentinization seems to have followed at a lower temperature and finally ensued silicification, the solutions having now become acid. It is possible, and even probable, that silicification went on in part contemporaneously with the other processes, but under different physical conditions. The evidence, however, is on the whole against the supposition that the silicified rocks now exposed were thus modified contemporaneously with the formation of the basic metamorphic rocks of the present surface. Chloritization and impregnation with calcite and gypsum are still going on at ordinary temperature.

In conclusion it may be noted that all the more important minerals of the Archean schists are found in the metamorphosed rocks of the Coast Ranges. The quantitative relations indeed are different, especially those of the feldspars; for while orthoclase predominates in the Archean, plagioclase is much more common in the Coast Ranges. There is far less evidence of great pressure in the quicksilver belt than in most Archean areas, and the intensity of chemical action has been much less uniform; but it is evident that under conditions not greatly dissimilar to those which prevailed in California at the close of the Neocomian, rocks not distinguishable from those of Archean areas might have been formed. Indeed more than one eminent geologist has believed that he recognized the rocks in question as Archean. It does not follow, however, to my mind, that all Archean rocks are necessarily of an origin similar to that of the metamorphosed rocks of the Coast Ranges.

San Francisco, Office U. S. Geol. Survey, Feb., 1886.

Art. XXXIII.—ARNOLD GUYOT.*

It is a remarkable fact in the history of American Science that, forty years since, the small Republic of Switzerland lost, and America gained, three scientists who became leading men of the country in their several departments—Agassiz in Zoology, Guyot in Physical Geography, and Lesquereux in Paleontological Botany; Agassiz coming in 1846, Guyot and Lesquereux in 1848. A fourth, Mr. L. F. de Pourtalès, who accompanied Agassiz, also merits prominent mention; for he was "the pioneer of deep-sea dredging in America."† The Society of the Natural Sciences at Neuchâtel lost all four. As an American Academy of Science we cannot but rejoice in our gain; but we may also indulge at least in a passing regret for Neuchâtel, and recognize that, in the life and death of Agassiz, Pourtalès and Guyot, we have common interests and sympathies.

My own acquaintance with Professor Guyot commenced after his arrival in America, when half of his life was already passed. In preparing this sketch of our late colleague, I have therefore drawn largely from others, and chiefly from his family, and a memorial address by Mr. Charles Faure of Switzerland, one of his pupils, which was published in 1884 by the Geographical Society of Geneva.‡

Youth—Education in Switzerland and Germany, 1807 *to* 1835. —To obtain a clear insight into the character of Professor Guyot it is important to have in view, at the outset, the fact that the Guyot family, early in the sixteenth century, became protestants through the preaching of the French reformer, Farel, the cotemporary of Luther; and also the sequel to this fact, that at the revocation of the Edict of Nantes, the Guyots were one of sixty families that moved into the principality of Neuchatel and Valangin from the valleys of Pragela and Queyraz in the high Alps of Dauphiny. Thus the race was one of earnestness and high purpose, of the kind and origin that contributed largely to the foundations of the American Republic.

Professor Guyot's father, David Pierre, esteemed for his "prompt intelligence and perfect integrity," married in 1796 Mademoiselle Constance Favarger, of Neuchatel, "a lady of

* From a biographical sketch by James D. Dana, prepared for the U. S. National Academy of Sciences, and read by Professor C. A. Young at the meeting in April at Washington.

† Mr. Alexander Agassiz, this Journal, III, xx, 254, 1880.

‡ Vie et Travaux d' Arnold Guyot, 1807–1884, par Charles Faure. 72 pp. 8vo. Read before the Geographical Society of Geneva, April 25 and Aug. 25, 1884.

great personal beauty and rare nobility of character." Arnold-Henri, one of twelve children, was born at Boudevilliers, on the 28th of September, 1807, and was named after the Swiss patriot of the fourteenth century, Arnold von Winkelried. About 1818, the family moved to Hauterive, three miles from Neuchâtel, where his father died the following year. From the house at Hauterive young Guyot had before him, to the southeastward, the whole chain of the Alps from Mt. Blanc to Titlis, and his sensitive nature must have drawn inspiration from the glorious view; the same deep draughts that he attributed to young Agassiz, in his Academic memoir of his friend, with reference to the same circumstance—the snowy Bernese Oberland, the Jungfrau, the Schreckhorn, the Finsteraarhorn, the Eigers, and other summits to Mt. Blanc, "looming up before his eyes in the view from his house." Such views are calculated to make physical geographers and geologists of active minds. Guyot early found pleasure in the collection of insects and plants, and evinced in this and other ways the impress that Nature was making upon him.

Previous to the year 1818 and for a while after, Guyot was at school at La Chaux-de-Fonds, a noted village "at the foot of a narrow and savage gorge of the Jura," 3,070 feet above the sea. In 1821, then fourteen years of age, he entered the College of Neuchâtel, where he was a classmate of Leo Lesquereux, the botanist. "Guyot and I," says Lesquereux, "were for some years brothers in study, working in common, and often spending our vacations together either at Guyot's home at Hauterive, or with my parents at Fleurier, and I owe much in life to the good influences of this friendship." His studies were classical—Latin, Greek and philosophy, arranged for preparing a boy for the profession of the law, medicine or theology, with almost nothing to foster his love of nature.

In 1825, then eighteen, he left home to complete his education in Germany. After spending three months in Metzingen, near Stuttgart, in the study of the German language, he went to Carlsruhe, where he became the inmate of the family of Mr. Braun, a man of wealth and scientific tastes, the father of the distinguished botanist and philosopher, Alexander Braun, the discoverer of phyllotaxis—terms of intimacy with the family on the part of several of his relatives having been of long standing. The family comprised also a younger son and two daughters. Agassiz was then a student at Heidelberg, along with young Alexander Braun and Carl Schimper, but he spent his summer vacations at the Carlsruhe mansion. A vacation soon came. "The arrival of the eldest son of the house," says Guyot, "already distinguished by his scientific publications, with his three university friends—Agassiz, Schimper, the

gifted co-laborer of Braun in the discovery of phyllotaxis, and Imhoff of Bâle, the future author of one of the best Entomological Faunas of Switzerland and Southern Germany, was a stirring event, which threw new life into the quiet circle. "After a short time devoted to a mutual acquaintance, every one began to work. The acquisition of knowledge was the rule of the day, and social enjoyment was but the sweet condiment to more solid food." "My remembrance," remarks Guyot, "of those few months of alternate work and play, attended by so much real progress, are among the most delightful of my younger days." "Add to these attractions the charm of the society of a few select and intimate friends—professors, clergymen and artists, dropping in almost every evening, and you will easily understand how congenial, how fostering to all noble impulses, must have been the atmosphere of this family for the young and happy guests assembled under its hospitable roof." "Months were thus spent in constant and immediate intercourse with nature, the subjects of investigation changing with the advancing seasons. Botany and Entomology had their turn; "and demonstrations of phyllotaxis," he says, "now reduced to definite formula by Braun and Schimper, and shown in various plant forms, but especially in pine cones, were of absorbing interest. The whole plan of the present animal kingdom in its relations to the extinct paleontological forms was the theme of animated discussions." He adds: "It would be idle to attempt to determine the measure of mutual benefit derived by these young students of nature from their meeting under such favorable circumstances. It certainly was great, and we need no other proof of the strong impulse they all received from it than the new ardor with which each pursued, and subsequently performed, his life-work."* Guyot took in, equally with Agassiz, the newly developed views in botany, embryology and zoological classification, that were the subjects of thought and discussion, and became profoundly impressed thereby, as his later work shows.

From Carlsruhe, Guyot went to Stuttgart and took the course at the Gymnasium, where he made himself a proficient in the German language.

Returning to Neuchâtel in 1827, and there quickened in his religious faith and feelings by the preaching of the Rev. Samuel Petit-pierre, his benevolent impulses under a sense of duty led him to turn from science to theology, and commence serious preparation for the ministry. In 1829, then 22 years of age, having this purpose still in view, he went to Berlin to attend the lectures of Schleiermacher, Neander and Hengstenberg, and there remained for five years (1830–1835). In order to

* Guyot's Academic Memoir on Agassiz, pp. 8–12.

meet his expenses he accepted the invitation of Herr Müller, Privy Counsellor of the King of Prussia, to live with him and give his children the benefit of conversation in French. The position brought him into intercourse with the highest of Berlin society, and was in many ways of great benefit to him.

While pursuing theology in earnest, his hours of recreation found him making collections of the plants and shells of the country and otherwise following his scientific leadings. Humboldt introduced him to the Berlin Botanical Garden, where the plants of the tropics were a source of special gratification and profit. Moreover, other courses of lectures attracted him, as those of Hegel, of Steffens on Psychology and the Philosophy of Nature, Mitscherlich on Chemistry, Hofmann on Geology, Dove on Physics and Meteorology, and especially those of Carl Ritter, the eminent geographer, whose philosophical views were full of delight to his eager mind and touched a sympathetic chord. Under such influence he found his love for nature-science rapidly taking possession of him, and, yielding finally to his mental demands, and to his conscience which would not permit him to enter the ministry with a divided purpose, he determined to drop theology and make science his chief pursuit.

Ritter, of all his Berlin teachers, made the profoundest impression on his course of thought; and his biographical sketch of him, presented to the American Geographical Society in 1860, four years after his death, exhibits the admiring affection of a pupil who was like Ritter in his profounder sentiments. A paragraph from the Memoir will show the tenor of Ritter's geographical teaching, and something of the mental affiliation between them. Guyot says:*

"Ritter, in the introduction to the 'Erdkunde,' declares that the fundamental idea which underlies all his work, and furnishes him a new principle for arranging the well-digested materials of the science of the globe, has its deep root in the domain of faith. This idea, he adds, was derived from an inward intuition, which gradually grew out of his life in nature and among men; it could not be, beforehand, sharply defined and limited, but would become fully manifested in the completion of the edifice itself. That noble edifice is now before us, and unfinished though it be, it reveals the plan of the whole and allows us to perceive that fundamental idea on which it rests. It is a strong faith that our globe, like the totality of creation, is a great organism, the work of an all-wise Divine Intelligence, an admirable structure, all the parts of which are purposely shaped and arranged, and mutually dependent, and like organs, fulfill, by the will of the Maker, specific functions which combine themselves

* Amer. Geographical Soc., ii, p. 48, Feb., 1860.

into a common life. But, for Ritter, that organism of the globe comprises not nature only; it includes man, and with man, the moral and intellectual life." "None before him perceived so clearly the hidden but strong ties which mutually bind man to nature; those close and fruitful relations between man and his dwelling-place, between a continent and its inhabitants, between a country and the people which hold it as its share of the continent; those influences which stamp the races and nations each with a character of their own, never to be effaced during the long period of their existence."

We have here ideas that took, in Guyot, a still larger expansion.

Guyot derived great profit also from the works and the friendship of Humboldt. His address at the Humboldt Commemoration of the American Geographical Society, in 1859, is a beautiful tribute to this model student of nature.*

The five years of study at the Berlin University terminated with an examination which brought him the degree of Doctor of Philosophy. His graduating thesis, written in Latin, as was then the rule, was on "the Natural Classification of Lakes."

To Paris, the Pyrenees, Italy, etc., 1835 *to* 1839.—From Berlin, Guyot, in his 28th year—June of 1835—went to Paris to take charge of the education of the sons of Count de Pourtalès-Gorgier, and continued with the family four years. Letters of introduction from Humboldt led to much intercourse with Brongniart and other savants of the great city. For the summer he accompanied the family to Eaux Bonnes in the Pyrenees. While there he made ascents of the higher peaks, and took excursions in various directions—to the amphitheater of Gavarnie, to the borders of Spain by the Pont d'Espagne and the pass beyond, to the valley of the Eaux Chaudes, etc.—in order to study the features and flora and compare the mountains in these respects with the Alps. In the autumn he went, with his pupils, to Belgium, Holland and the Rhine, to study the characteristic features of these countries. The following year he visited Pisa, and there, besides enjoying the new scenes, made various barometrical measurements, determining the elevation of the observatory at Florence, and of other points.

Trip to the Glaciers in 1838.—In the spring of 1838, Agassiz found Guyot still at Paris. During the summer preceding Agassiz had startled the scientific world by his declarations as to a universal Glacial era, contained in a paper read before the Helvetic Society of Natural Sciences assembled at Neuchâtel. His work in 1837—prompted in 1836 by Charpentier's discoveries proving the fact of a former epoch of immense glaciers in

* Journal of the American Geographical Society, i, 242, October. 1859.

Switzerland—had led him to the bold conclusion; and he was full of his new ideas when he met his old companion. He urged Guyot, who hesitated at accepting his views without examination, to study the facts; and obtained the promise that he would visit the glaciers that summer.

In his memoir of Agassiz, Guyot states that his six weeks of investigation that season in the central Alps (nearly two years before Agassiz commenced his investigations on the glacier of the Aar) were fruitful beyond expectation. He says, that from the examination of the glaciers of the Aar, Rhone, Gries, Brenva and others, he learned (1) the law of the moraines; (2), that of the more rapid flow of the center of the glacier than the sides; (3), that of the more rapid flow of the top than the bottom; (4), that of the laminated or ribboned structure ("blue bands"); and (5) that of the movement of the glacier by a gradual molecular displacement, instead of by a sliding of the ice-mass as held by de Saussure.

The facts and conclusions were communicated to the Geological Society of France at a meeting at Porrentruy in September, 1838. The communication is mentioned in the Bulletin of the Society for that year;* but no report of it is given, because the manuscript remained in his hands unfinished in consequence of his protracted illness the winter following. The portion then finished (which afterward was withheld from publication because, by special arrangement between them, Agassiz, in 1840, entered upon the special study of the glacier, and Guyot on that of the Swiss erratic phenomena, for their separate parts of a general survey) has recently been printed in volume xiii (1883) of the Bulletin of the Neuchâtel Society of Natural Sciences.

In 1842 this manuscript was deposited, by motion of Agassiz, in the archives of the Neuchâtel Society, and in 1848 it was withdrawn by Guyot when he left for America. It is to be regretted that publication was not substituted in 1842 for burial. Its recent publication was made by the request of Guyot early in 1883 from a certified copy of the original manuscript.

This paper gives the facts on which Guyot based his conclusions; and since these conclusions comprise some of the most important of the views now accepted relating to glacier motion and structure, and antedate the observations of Agassiz, Rendu and Forbes, they have special interest.

The fact of *a less rapid movement of the bottom ice than the top, owing to friction*, he ascertained by the observation that in glaciers of steep descent, like the Rhone at its rapids, and the Gries, the transverse crevasses and the masses they cut off are

* Volume ix, page 407.

at first vertical or nearly so; but below the rapids, where the slope is gentle and the crevasses become mostly closed, the masses are inclined with the pitch up stream; and this up-stream inclination is reduced, at the termination of the glacier, to a few degrees. The crevasses, although closing up below, are still traceable. He says: The so-called layers are not strictly layers; but great numbers of cracks remain which give to the mass the appearance of being made up of beds several yards thick, as may be seen in the glaciers of the Grindelwald valley, Aar and others.

Further: to this pitch in the stratification at the lower extremity, the beds rising outward, Guyot attributes also the origin of the majestic ice-chambers, whence in most cases flow great streams, as that of the Rhone, of the Arveyron at the foot of the Mer de Glace, of the Lütschinen from the glaciers of Grindelwald.

The more rapid movement of the center than the sides also was learned from the Rhone glacier and others of steep descent. The crevasses, at first transverse, were found to be arched in front below the rapids, and increasingly arched to the extremity, and the successive crevasse lines were very nearly concentric with the semicircular outline of the extremity of the glacier. He gives a figure of the Rhone glacier as seen from the Maienwand in illustration; and other later glacialists have appealed to the same evidence of lateral friction.

The semicircular outline of the terminal moraine was found to be another result of the cause just mentioned; and so also the "eventail" arrangement of the several moraines immediately above the termination. The greater height and breadth of the central moraine is made a consequence of the greater velocity of the ice at the middle of the upper surface, more transportation taking place consequently in a given time.

Again: The conclusion that *the movement of the glacier was largely through molecular displacement* was supported by his observation that the ice, instead of breaking up and rising into an accumulation of masses on its passage by an isolated rock, or rocky islet in its course, spread around and enveloped it without fracturing; and he refers to a fine example of this at the two isolated islets of rock in the midst of the great Brenva glacier, called the "Eyes of the glacier." "The same thing is observed at the Jardin du Talèfre, a true islet in the midst of a *mer de glace*, having a border of blocks of rock, or of a moraine, cast upon its sides by the march of the glacier, just like the coast dunes of an island in the ocean."

In view of such facts Guyot observes: "If it is true that the different parts of a glacier move with different velocities; if the glacier adapts itself to the form of a valley and fills all depres-

sions without ceasing to be continuous; if it can bend around an obstacle and closely enclose it without the fracturing of its mass like a spreading liquid, we may affirm that the movements take place through a molecular displacement, and we must abandon, at least as the only cause, the idea of a slow sliding of the mass upon itself as incompatible with the phenomena presented."*

The *blue bands* of the glacier were first described by Guyot. He called the structure *stratification*, and observed it in the ice of the summit of the glacier of Gries, at a height of about 7500 feet. A peculiar furrowing of the surface of the ice, the furrows one or two inches broad, attracted his attention; and this result of weathering he found to have come from the unequal firmness of the layers constituting it, layers of a softer "snowy ice" alternating with those of firm bluish glassy ice. The stratification was found by him to extend over hundreds of square meters, and downward, on the sides of crevasses, 20 to 30 feet deep, or as far down as the eye could penetrate; and it was evident that the layers of the two sides of a crevasse were once continuous, "like the strata of the opposite sides of a transverse valley." He compared the stratification to that of certain coarsely schistose limestones.† He remarks in conclusion: "We should say that the layers were not annual layers, but rather a series made day by day from small successive snow-falls that were melted in part by the sun of the day, and covered each night by the thick frost-glazing which envelops all the snowy summits of the high Alps."‡

He further observes that "these beds were evidently formed at a greater height and in a different position from that where observed." He adds, in closing his remarks on the subject—"Do the beds, at first horizontal, or at least parallel to the surface of the glacier, accomplish, during its movement, evolutions, as yet imperfectly understood, analogous to those before mentioned [that is, those occasioned by differences in velocity of the middle, sides and bottom, owing to unequal friction]. This is a point which should have further examination, with observations as minute, numerous and universal as possible. Unfortunately a thick fog and threatening weather forced me

* In French his words of 1838 are: "On peut affirmer que ces mouvements ne peuvent avoir lieu qu'en vertu d'un déplacement moléculaire, et il faut abandonner, au moins comme cause unique, l'idée d'un glissement lent de la masse sur elle-même, comme incompatible avec les phénomènes que presente la marche des glaciers."

† His words are: "stratifié à la façon de certains calcaires grossièrement schisteux;" and he explains it himself as implying a *lamellar structure*.

‡ In the original, the words are: On aurait dit, non pas des couches annuelles, mais une série de couches plutôt journalières de neige tombée successivement par petites quantités, puis fondue en partie par le soleil de la journée, et couverte chaque nuit de cet épais verglas qui, au-dessus de la région des glaces, recouvre toutes les sommités neigeuses des hautes Alpes."

to stop work before I had ascertained whether this structure was general for the whole mass of the glacier at that altitude, or whether restricted to that locality notwithstanding the proof of so large an extension of it." Guyot had some confidence in his conclusions, but he also felt, as he states, the importance of more detailed investigation in order to decide on their real value.

On the 1st of December, 1841, Guyot communicated the results of his observations of 1838, so far as relates to the "blue bands," at a meeting of the Neuchâtel Society of Natural Sciences—"reading some passages from his notes written in 1838." This communication contains the additional fact that the layers of the stratification in the Gries glacier were inclined about 45°; were nearly transverse to the principal glacier; and appeared also to have sinuosities due to lateral compression.* Agassiz, in his Systême Glaciaire (1847), cites from Guyot's manuscript (then deposited with the Neuchâtel Society) the part relating to the "blue bands" (the only part he ever cited); and in this citation there is a paragraph on the inclination or pitch of the layers, with Guyot's additional suggestion that the pitch of the layers looked as if a result of the advance of the surface portion over that below, a point already explained by him [by reference to friction at bottom.†]

Guyot opens his account of the blue bands with the remark that as he had seen them only on one occasion, he dares not hazard an explanation. But his later sentences show that he was inclined to regard them as a result of deposition, and to consider the varying inclinations in the layers as due to subsequent disturbing action, that is, to the irregularities of glacier movement caused by friction and pressure under the varying conditions of the glacier valley as to form and size.

Whether right or wrong in these suggestions as to the bands, Guyot's six weeks' work in the summer of 1883 was indeed fruitful. He had the satisfaction of seeing his conclusions for the most part confirmed by the facts collected by Agassiz, Forbes and others, but not of receiving credit for his work and

* The report of the meeting of the Neuchâtel Society is contained in the Verhandlungen of the Schweiz. Nat. Gesellschaft, Altdorf, 1842. The *abstract* of Guyot's communication here given (pp. 199–200) says: "La position de ces couches etait inclinée d'environ 45° dans le sens de la pente générale du glacier. Leur direction semblait presque transversale a celle du glacier principale, mais longitudinale à celle de son penchant méridional. Elle présentait quelquefois des sinuosités qui semblaient un effet de compression laterale."

† The cited paragraph in the Systême Glaciaire (p. 209) is as follows: "La direction de ces couches coupait à angle droit la ligne de marche (de pente) du glacier; leur inclination deviait de 30° à 40° de la perpendiculaire vers la partie inférieure, comme si la pente superficielle gagnait de l'avance sur la partie inférieure ainsi que je l'ai décrit plus haut." I learn from Mrs. Guyot that this paragraph is a part of the original manuscript, and that it was by oversight that it was not sent to the Neuchâtel Society in 1883 with the rest.

original conclusions, except on one point; and chiefly because of the want of proper publication.*

Having attended at Berlin, the lectures of Dove on Physics and Meteorology, and those of Ritter on Physical Geography, Guyot knew, when he went to the mountains, what to look for in case the glaciers were great flowing streams of ice, as had often been supposed; he knew that the flow of a stream is retarded along the sides and bottom by friction; and he naturally looked also for something in the encounter of the glacier with rocks answering to molecular displacement. Hence, in his six weeks of observations on the glaciers, he reached, without waste of time, good conclusions—the conclusions of a physical geographer. His investigation did not enable him to appreciate the interior fracturing that works along with molecular displacement in the flow of the ice, but his conclusion was still far in the right direction, and decisive against the hypothesis he opposed. That he did not continue his study of the glaciers to thoroughly established results was owing to his yielding the subject afterward to Agassiz. Fidelity to his friend and his volunteered agreement curbed in and silenced

* Rendu's "Théorie des Glaciers de la Savoie" was published in 1841 (Mem. Soc. Roy. Savoie, Chambery, vol. x). Forbes's first letter from the Alps, announcing his discovery in August, 1841, of the "blue bands" in the Aar glacier, was communicated to the Royal Society of Edinburgh, Dec. 6, 1841, and published in January in Jameson's N. Phil. J., vol. xxxii, 1842. Agassiz's first work on glaciers, "Études sur les Glaciers" was published in 1840. Neither of these publications mentions Guyot or his observations.

Guyot's communication of 1841, published in the Altdorf Verhandlungen, was drawn out by a discussion between Forbes and Agassiz relating to priority as to observations on the blue bands, and it was made just five days before Forbes's first letter was read in Edinburgh. Agassiz claimed credit for Guyot at the meeting in 1841, as a set off against Forbes's claim, and, again, in the N. Phil. Journ., xxxiii, 265, 1843. Forbes, in the following volume of that Journal, xxxiv, 145, 1843, gives Guyot credit for original discovery as regards the "blue bands" and speaks of his corresponding with him on the subject; and he repeats the acknowledgment to the "ingenious Professor of Neuchâtel," in his Travels through the Alps of Savoy, 1843 (1st edit.) and 1845 (2d edit.), page 28. Desor in the same Journal, xxxv, 308, 1843, in a paper on Agassiz's recent glacier researches, introduces a translation of Guyot's account of the banded structure, but cuts it short at the words "opposite sides of a transverse valley," leaving off the explanatory remarks which follow.

Tyndall, in his "Forms of Water" (1872, p. 183) gives Guyot credit for priority, and he cites, both in this work and in his earlier "Glaciers of the Alps" (1856), a translation of Guyot's account, ending it a sentence short of Desor's citation, with the words "certain calcareous slates," in place of Guyot's "certain schistose limestones;" and, on page 187 of "The Forms of Water," not knowing all of Guyot's explanations, he does him more than credit (admitting Tyndall's view to be established) in saying that he "threw out an exceedingly sagacious hint when he compared the veined structure to the cleavage of slate rocks:" for the comparison in Guyot's paper implies rather true stratification from deposition. The first detailed comparison of the "blue bands" to slaty cleavage, in structure, position and origin, appears to have been made by Professor Henry D. Rogers. at the Cambridge meeting of the American Association in 1849 (Proc. Am. Assoc., ii, 181). But Rogers attributed the structure in both to conditions of temperature, and not, like Tyndall, to pressure.

him; and so his paper, excepting the paragraphs on the "blue bands," remained buried until after Agassiz's decease.

At Neuchâtel—Professor in the Academy, 1839–1848.—In 1839, at the age of thirty-two, Guyot left Paris and returned to his native town. He at once became an active member of the Society of the Natural Sciences (which had been initiated by Agassiz in 1832), and was made, by the Society, one of a committee—including also M. A. Osterwald and H. Ladame—for the organization of a system of meteorological observations in Switzerland and the selection of the best instruments for the purpose. On the establishment of the "Academy" at Neuchâtel for the purpose of furnishing a university education to the graduates of the college or gymnasium, he was appointed to the chair of History and Physical Geography, and became a colleague of Agassiz. He hesitated about taking charge of the department of History, as it had not been one of his special lines of study; but once committed to it, he plunged into the subject with great earnestness. He says, he groped on among the details for two years before he began to distinguish its grand periods; and the light as it broke in upon him caused so intense excitement that he was made ill.

Instruction was a great pleasure to him, because of his deep interest both in his subject and in his pupils. His two departments called out from him thirteen general and special courses of lectures. With regard to the lectures, Mr. Faure says: "From the first, in spite of his apprehensions, he captivated his audience by his easy, elegant, sympathetic words, by the breadth of his views, and the abundance and happy arrangement of his facts. He had each winter afterward the pleasure of seeing men of cultivation of all classes in Neuchâtel pressing into the large hall of the college and listening to him with riveted attention." His pupil adds: "What zeal he inspired! What ardor for work! The fire with which he was filled passed to us. He was more than a professor; he was a devoted friend, a wise counsellor, associating himself with us and encouraging us in our work."

Guyot, besides lecturing and instructing, did all he could of outside work: meteorological, barometric, hydrographic, orographic and glacialistic. The hydrographic work was the careful sounding of Lake Neuchâtel (in all 1100 soundings) as the commencement of a study of the annual variation in the temperature of the waters of the Swiss lakes. His chief research—that on *the distribution* of the bowlders or erratics over Switzerland, occupied him "single-handed, seven laborious summers, from 1840 to 1847," he allowing himself, only "at the end of his working season, the pleasure of a visit of a few days to the

lively band of friends established on the glacier of the Aar, in order to learn the results of their doings and communicate his own to them."*

Switzerland in the ice-period was his subject; and the sources of the bowlders and the courses of ice-transportation were the chief enquiries. The investigation involved excursions on foot and careful examination over the whole range of the Swiss Alps, the slopes into Italy, the plains of Switzerland, and the mountains on the northern and western borders, including the Juras—in all an area of 190 by 310 miles—in order to trace the erratics to their high sources among the snowy summits, examine the rocks of all peaks, ridges and valleys for comparison with those of the erratics, measure the heights along the lines and limits of the erratics from plain to mountain peak, and note all glacial markings. The task was accomplished with the greatest possible fidelity; thousands of barometric measurements were made in the course of it, and from 5000 to 6000 specimens were gathered in duplicate.

Thus, says Guyot:

Eight erratic basins were recognized on the *northern* slope of the Alps—those of the Isère, the Arve, Rhone, Aar, Reuss, Limmat, Sentis, and Rhine; and four on the *southern* slope—that of the Adda including Lake Como, of Lugano, of Ticino including L. Maggiore, and that of the Val d'Aosta. Moreover a question left hitherto untouched—the distribution in each basin of the rocks special to it, was minutely examined, and the final results of all the laws observed in the arrangement of the erratic fragments were shown to be identical with the laws of the moraines. This identity, and the absolute continuity of the erratic phenomena from the heart of the Alps down the valleys and beyond to the Jura left no alternative but to admit the ancient existence of mighty glaciers as vast as the erratic regions themselves, having a thickness of over 2000 feet.

Brief notes on his work were published in the Bulletin of the Neuchâtel Society of the Natural Sciences, for November, 1843, May and December, 1845, and January, 1847,† he reserving the complete report for the *second* volume of Agassiz's great work on glaciers. But, unfortunately, after the first volume by Agassiz appeared at Paris, in 1847, there came the revolution of 1848, which put an end to their plans.

The study of the geological structure of the Jura Mountains, in which he worked out the system in the flexures of the strata and proved that it must have been produced by lateral pressure, was another of Guyot's labors soon after his return to

* Memoir of Agassiz, page 39.

† The facts are well presented also, though briefly, in the second volume of D'Archiac's Histoire des Progrès de la Géologie, pp. 259–265.

Neuchâtel, although not reported on until 1849, at the Cambridge meeting of the American Association.*

Guyot had been teaching at Neuchâtel nine years when, suddenly, the "Academy" was suppressed by the Grand revolutionary Council at Geneva of 1848. The 13th of June brought the tidings; and on the 30th, the end came "without any indemnity to the Professors." Letters from Agassiz urged Guyot to come to America. Though reluctant to take the step because of the many ties of friendship and association that bound him to Switzerland, and especially on account of the family under his charge (consisting of his mother, then 70 years old, and two sisters), which he should have to leave behind, he had the decision of his mother, after her careful reading of Agassiz's letter, in favor of it; and in the following August he left friends, home, and Europe.

ART. XXXIV.—*On the Determination of Fossil Dicotyledonous Leaves;* by LESTER F. WARD.

FRAIL as mere leaves would seem to be as objects to be preserved in the rocks of the earth's crust, observation shows that of all organs of vegetation they are the most numerous in the plant-bearing beds of recent formations. The fact being known the explanation is easy. The two chief conditions to preservation are firmness of consistency and rapidity of deposition. A large or thick body is longer in being covered up and in order to escape decay before burial it must have firmness and durability of structure proportionate to the time required. Hence it is that fruits and twigs of any considerable thickness are rarely found except in such formations as bear evidence of having been suddenly or rapidly deposited, like travertines, tufa-beds, etc. In beds of slow formation as a rule only leaves are found. Those that give proofs of having been evergreen are most numerous because of the firmer consistency of evergreen leaves. But deciduous leaves also occur, partly perhaps because the chances are increased by the greater number that annually fall, and partly because thinner and more quickly covered. We thus have, in many parts of the world, large deposits of dicotyledonous leaves ranging from the Cenomanian to the Quaternary, in which no other organs are preserved.

The great importance, therefore, of finding some characters in these leaves which can be depended upon to reveal their relationships becomes obvious, and this was early perceived.

* Proc. Amer. Assoc., ii, 115.

It being evident that the mere form or outline of leaves does not furnish the characters required these were sought in the disposition of the fibro-vascular bundles commonly called the *nervation.* A. P. DeCandolle in 1827 had classified leaves according to their nervation as an important factor in vegetable organography, but vegetable paleontologists had not yet made use of nervation for the identification of fossil leaf-prints. These were all grouped together by Sternberg under his name of *Phyllites* and his successors had been content to follow in his footsteps.

In 1838 Dr. G. Bianconi published an important paper on this subject in the Nuovi Annali delle Scienze naturali of Bologna (Ann. I, tom. i, p. 343) in which he made a direct application of the nervation to the study of fossil leaves.

Two years later Rossmässler's "Versteinerungen des Braunkohlensandsteins aus der Gegend von Altsattel in Böhmen" appeared, in which a large number of such leaves are very carefully figured. Rossmässler suggested, but did not adopt, the plan of calling such plants by generic names composed of the name of the genus of living plants presumed to be nearest related, with the old word *phyllites* appended as a termination, for example, *Daphnophyllites* for leaves resembling Daphne, etc. "In this way," he says, "all possible repetition of a name already in use would be avoided, we should recognize the name as belonging to the ancient world, and they would announce themselves as the names of leaf-genera."

Brongniart (Prodrome, p. 209) had set the example of calling some of these leaf impressions by the names of living genera, and this was followed to some extent by Dr. Alexander Braun in determining the well-preserved specimens from the Oeningen beds, and more extensively by Dr. Franz Unger in studying those of Radoboj, Parschlug and Bilin. In January, 1852, Leopold von Buch submitted to the Royal Academy of Sciences at Berlin (Monatsbericht, 1852, p. 42) an important paper on the nerves of leaves and the laws of their distribution, which may have furnished the impetus for Baron von Ettingshausen's extensive and fertile researches in this line which began to be published in 1854, and in the prosecution of which he has availed himself so successfully of the art of nature-printing, or physiotypy. These researches and their constant application to the identification of fossil plants are too well known to require mention here, as are also those of the late Dr. Oswald Heer in making known the fossil floras of Switzerland and the arctic regions.

These investigators and their able contemporaries, Saporta, Lesquereux, Engelhart and others have described a vast number of species from leaves alone and referred them to living

genera. In many cases they have done this for Eocene, and even for Cretaceous fossils, where the form and nervation seemed to justify it. In Heer's arctic work this was sometimes done from incomplete fragments, and there are cases in which this has been afterward confirmed by the discovery of more complete material.

But carefully as the laws of nervation have been worked out and laid down in systems, there is no one who does not feel that we are indebted more to the extraordinary skill and penetration of the authors of these systems in reaching correct conclusions through their intuitive perceptions than we are to any power which such rules unaided by such perceptions can give to reach reliable results. Moreover, the investigator who above all others possessed this intuitive instinct, Professor Oswald Heer, is no longer in the field, others who so successfully labored with him have reached an advanced age and must ere long cease their labors, while younger men are springing up in many lands to take up and continue a work which seems as yet to have been only just begun.

In such a field, from which if properly cultivated such rich harvests may be expected for science, which yet depends so largely upon the personal qualities of the investigator, it becomes of the utmost importance that sound and safe methods be adopted, and that if any unsound or unsafe methods have been employed, as it may well be expected that there have been during the early history of the science, they be revised or rejected and new and better ones introduced.

It is doubtless with a keen sense of this truth that Dr. A. G. Nathorst of Stockholm, upon whom Heer's mantle seems to have fallen, at least so far as the arctic fossil floras are concerned, in a very recent paper in the "Botanisches Centralblatt" (Band xxvi, 1886) lifts up a warning voice. It is not the first time that he has called a halt in the too rapid and confident march of paleontology. The great commotion which he so recently produced in the Silurian waters has as yet scarcely ceased, and this paper seems likely to create an almost equal disturbance in those of the Cretaceous and Tertiary.

Dr. Nathorst considers that in referring fossil leaves, where other organs are not known, to living genera vegetable paleontologists are in danger of claiming too much, and that the older the formation in which they are found the greater this danger is. He thinks that for Cretaceous species, such as those from the Cenomanian beds of Greenland and of Bohemia and from the Dakota group of the United States, such reference is wholly unjustifiable; and even for Eocene and Miocene plants he says that the material must be abundant and in an excellent state of preservation to warrant this course. He believes

that Heer and others have gone much too far in this direction, and he points especially to recent "determinations" by Ettingshausen of specimens from Australia (Denkschr. Wien. Akad. Bd. xlvii) and pronounces them worthless. And in this latter case, when we remember what important deductions relative to the character and distribution of the Tertiary flora are based upon these identifications in the same paper in which they are figured, we can scarcely complain that this criticism is too severe.

The remedy proposed by Dr. Nathorst for this state of things is the adoption of a new system of nomenclature. He lays down the rule that the generic name of a fossil leaf should indicate just what we know about it and neither more nor less. To call such leaves by the names of living genera is to say more about them than we know. To obviate this he proposes to employ composite names consisting of the name of the nearest living genus with the suffix *phyllum*, the first component of which will indicate the supposed relationship while the last will denote that the genus is founded on leaves only.

In addition to this Dr. Nathorst makes three other important recommendations, to which, however, very little objection will probably be raised. The first is that where leaf-impressions, apparently belonging to the same species, though differing slightly, are found in widely separated localities, the trinomial system be employed but without the abbreviation *var.*, which, as he justly remarks, implies that the one is a variety of the other, a statement which we have no right to make.

The second is that in all cases the types be carefully and thoroughly figured, so that even those who cannot see the original, can form a correct idea of their nature. To this end the surface and consistency of the leaf should be represented as accurately as possible, and the nervation should be shown even to the finest meshes, at least on some small part of the leaf, to indicate its true character. Mere contour lines are wholly inadequate for the determination of fossil leaves.

The third of these recommendations is that unless the specimens show good characters which admit of delineation and description they be regarded as indeterminable and no attempt be made to treat them as genera and species until better material is obtained.

Dr. Nathorst's paper concludes with an appeal to his colaborers in phytopaleontology to unite with him in securing the adoption of these standards.

In seriously considering these demands it is necessary to remember that we have a certain state of things to deal with which is the product of a slow growth. Those who will most readily admit that the system of nomenclature proposed is

theoretically far superior to the one we already have must nevertheless see that the attempt, in the existing condition of things, to supplant the latter by the former, or even to engraft the former on the latter, will be attended by grave practical difficulties. Dr. Nathorst speaks as though he had only reference to the future—to genera yet to be discovered and created. But it does not seem possible thus to limit it. There are now hundreds, probably a thousand, species referred to living genera which his rules would exclude. Are these to be left as they are? If this is attempted and the new method applied to subsequent species it will at once be found that species undoubtedly belonging to the same genus will be classed under two genera. We shall have Fagus and Fagiphyllum, Quercus and Querciphyllum, Salix and Saliciphyllum performing one and the same rôle in two parallel series. It is therefore clear that if the change is introduced at all it must be made retrospective. This, however, cannot properly be done except by the previous preparation of a systematic work in which all the cases shall be collected and unified. Under the present system of independent monographing of special floras unlimited confusion must result from any attempt to apply these new rules of naming. But the nomenclature of paleobotany is already in a bewildering state. Only to-day I met with a case in which no less than five different plants have been described under the same name (*Odontopteris neuropteroides*), two of these by one author from the same State, and the Mesozoic and Cenozoic species are only less confounded than the Paleozoic, so that it certainly is ample time that some all-embracing scheme of systemization were adopted. But as regards the plan proposed by Nathorst, which, it will be observed, differs but slightly in form and still less in principle from that suggested by Rossmässler in 1840, it is evident that before any steps can be taken looking to its introduction paleobotanists must know better how it is to be applied to the existing state of the science and what is to be done with the species already referred, however improperly, to living genera.

The chief objection that lies against *Phyllites* is that instead of denoting a natural genus it includes a great number of wholly unrelated genera. The use of the suffix *Phyllum* might often be open to the same objection. Two generically distinct forms might both resemble a living genus but manifest their deviation from it in precisely opposite directions. We should then have two clearly distinct genera bearing the same generic name.

The principle of creating extinct genera, the names of which connote their relationships with living ones has long been recognized by the use of the terminations *ites*, *oides*, *opsis*, etc., and some of these are founded on leaf specimens. Such would

require the substitution for these terminations of the new one *phyllum*. This would complicate matters, for many such genera have already been changed, and not a few are still in dispute, some authors treating them as identical with living genera. Schimper undertook to change all names in *ites* to *ides*, from considerations of etymological exactness, but he found such a trifling change as this so difficult that he abandoned it after the first volume, and in at least one case even then it had led to the introduction and separate description of the same genus twice (Paléontologie Végétale, vol. i, p. 579, Danæites, Göpp., p. 616, Danæides, Sch.). I mention these points in no spirit of cavil, but merely to illustrate with what practical difficulties any change in nomenclature is necessarily attended.

With at least one of the minor suggestions of this highly suggestive paper I think I can say without further reflection, and from my personal experience with the cases involved, that I do not agree. The writer correctly perceives that in many cases where the material according to his strict canons is indeterminable it may still be important to figure what we have in order to secure more general study and comparison, and he also, as I think, justly condemns the reference of all such cases to the meaningless ("*nichtssagende*") genus *Phyllites*, but I cannot go with him to the further length of recommending that these objects after having been described and figured be left entirely without names. We have thousands of such cases now and they are becoming very troublesome in the literature of the science. Names are useful however intrinsically meaningless, in enabling us to refer to the objects named and to find them when we want them; and anything that is worth figuring is worth naming. I would therefore treat such cases like the rest, and make provisional genera for them according to the same rules by which they are made for better preserved material. In practice there will be found to be no clear line of demarcation between determinable and indeterminable material, but a broad belt will exist over which it will be the one or the other according to the views of different investigators. And if it be said that these genera will mostly have to be abandoned, thus encumbering the books, the reply is that the path of this, as of every other branch of paleontology, is strewn with abandoned names which all served a useful purpose in their day. Moreover, what Dr. Nathorst has the courage to say relative to species, viz: that notwithstanding the popular opposition to multiplying species, the union of two impressions which do not belong together works more mischief than the separation of two that do belong together, will apply to genera as well as to species, and the dropping out of these provisional genera as their true affinities are ascertained will be attended with comparatively slight disturbance.

ART. XXXV.—*Pseudomorphs of Limonite after Pyrite;* by ERASTUS G. SMITH.

THE common hydrated oxides of iron generally referred to limonite are undoubtedly alteration products of ferrous oxide, or decomposition products of other iron-bearing minerals. Their secondary nature is clearly demonstrable in the various occurrences where crystalline form is yet retained, giving clearly defined pseudomorphs of ferric hydrate after the original mineral. Numerous occurrences of such pseudomorphs after various minerals are recorded.

The writer's attention has been called recently to such an alteration of pyrite into ferric hydrate, which is of special interest, as the crystalline form of the pyrite is sharply defined. A large number of the crystals were obtained—the largest cube being about one-fourth inch on a side. The color varies from a pale yellow to a dark brown, and in the largest nodule examined the exterior exhibited the peculiar glossy appearance commonly observed on limonite. The crystals occur through the lower layers of the upper Buff division of the Trenton limestone at Carpenter's Quarry, near Beloit, and partially line cavities distributed through the layers, the remaining space being in part filled with a finely granular calcareous sand. The limestone of these layers contains 2·23–1·42 per cent of mixed $Al_2O_3+Fe_2O_3$.* All stages of metamorphism are represented, repeated qualitative examination of smaller crystals giving no reaction for sulphur, while some of the larger ones retain a kernel of the bright yellow, but slightly altered, original pyrite. The simple cube (*i-i*) is the most common form, though traces of a pyritohedron were observed in some instances.

The following analysis is of a nodule weighing 26 grams. The exterior shows numbers of imperfect cubes, and the specimen is evidently merely a larger aggregate of the altered pyrite. Its sp. gr. = 3·45 (temp. 14° C.). (Limonite = 3·6–4; pyrite 4·82–5·2 Dana).

	I.	II.
Silica	06·25 per cent	
Sulphur (S)	00·31	00·25 per cent.
Ferrous oxide (FeO)	00·91	
Ferric oxide (Fe_2O_3)	80·21	
Calcium oxide (CaO)	00·04	
Magnesium oxide (MgO)	00·40	
Loss on ignition	11·72	
	99·84	

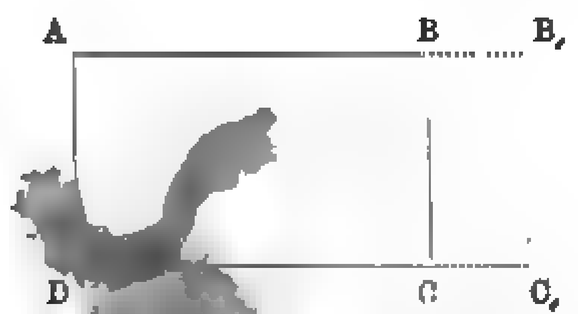
* Geol. Wisconsin, vol. ii, p. 298.

The metamorphism is therefore quite complete. On boiling the powdered mineral with sulphuric acid and oxidizing with potassium permanganate an amount of the standard solution was required corresponding to 0·91 per cent FeO as given. The ratio of FeO to S is very nearly 1 : 1. The traces of CaO and MgO are probably foreign. If the silica is combined with a part of the iron in the form of a silicate as usually considered, the water and the remaining ferric oxide are in approximately the ratio represented by the formula assigned to limonite, 14·4 per cent H_2O, 85·6 per cent Fe_2O_3. Kobell* gives an analysis of a similar pseudomorph from Minden, SiO_2 4·50, H_2O 13·26, Fe_2O_3 82·24 = 100·00 per cent. The loss on ignition, as determined in three different samples, gave 11·72, 11·90 and 11·15 per cent respectively. The last determination was of the powder from several small quite perfectly developed crystals.

Beloit College Chemical Laboratory, Beloit, Wisconsin, March, 1886.

ART. XXXVI.—*Influence of Motion of the Medium on the Velocity of Light;* by ALBERT A. MICHELSON and EDWARD W. MORLEY.†

THE only work of any consequence, on the influence upon the velocity of light of the motion of the medium through which it passes, is the experiment of Fizeau. He announced the remarkable result that the increment of velocity which the light experienced was not equal to the velocity of the medium, but was a fraction x of this velocity which depended on the index of refraction of the medium. This result was previously obtained theoretically by Fresnel, but most satisfactorily demonstrated by Eisenlohr,‡ as follows:



Consider the prism AC in motion relatively to the ether in direction AB with velocity θ. Suppose the density of the external ether to be 1 and of the ether within the prism, $1+\Delta$. In the time dt the prism will advance a distance θdt=BB, At

* J. pr. Ch., 1·319 (Rammelsberg, Mineral Chemie, 185).

† This research was carried on by the aid of the Bache Fund.

‡ Verdet. Conferences de Physique, ii, 687.

the beginning of this time the quantity of ether in the volume $BC_{\prime}$ (if S=surface of the base of the prism,) is $S\theta dt$. At the end of the time the quantity will be $S\theta dt(1+\Delta)$. Hence in this time a quantity of ether has been introduced into this volume equal to $S\theta dt\Delta$.

It is required to find what must be the velocity of the ether contained in the prism to give the same result. Let this velocity be $x\theta$. The quantity of ether (density$=1+\Delta$) introduced will then be $Sa\theta dt(1+\Delta)$ and this is to be the same as $S\theta dt\Delta$, whence $x=\dfrac{\Delta}{1+\Delta}$. But the ratio of the velocity of light in the external ether to that within the prism is n, the index of refraction, and is equal to the inverse ratio of the square root of the densities, or $n=\sqrt{1+\Delta}$ whence $x=\dfrac{n^2-1}{n^2}$ which is Fresnel's formula.*

* The following reasoning leads to nearly the same result; and though incomplete, may not be without interest, as it also gives a very simple explanation of the constancy of the specific refraction.

Let l be the mean distance light travels between two successive encounters with a molecule; then l is also the "mean free path" of the molecule. The time occupied in traversing this path is $t=\dfrac{a}{v_{\prime}}+\dfrac{b}{v}$, where a is the diameter of a molecule, and $b=l-a$, and $v_{\prime}$ is the velocity of light within the molecule, and v, the velocity in the free ether; or if $\mu=\dfrac{v}{v_{\prime}}$ then $t=\dfrac{\mu a+b}{v}$. In the ether the time would be $t_{\prime}=\dfrac{a+b}{v}$, hence $n=\dfrac{t}{t_{\prime}}=\dfrac{\mu a+b}{a+b}$. (1)

If now the ether remains fixed while the molecules are in motion, the mean distance traversed between encounters will no longer be $a+b$, but $a+\alpha+b+\beta$; where α is the distance the first molecule moves while light is passing through it, and β is the distance the second one moves while light is moving between the two. If θ is the common velocity of the molecules then $\alpha=\dfrac{\theta}{v_{\prime}}a$, and $\beta=\dfrac{\theta}{v-\theta}b$. The time occupied is therefore $\dfrac{a}{v_{\prime}}+\dfrac{b}{v-\theta}$ or $\dfrac{\mu a}{v}+\dfrac{b}{v-\theta}$. The distance traversed in this time is $a+b+\left(\dfrac{\mu a}{v}+\dfrac{b}{v-\theta}\right)\theta$; therefore the resulting velocity $v=\dfrac{a+b}{\dfrac{\mu a}{v}+\dfrac{b}{v-\theta}}+\theta$.

Substituting the value of $n=\dfrac{\mu a+b}{a+b}$ and neglecting the higher powers of $\dfrac{\theta}{v}$, this becomes
$$v=\frac{v}{n}+\left(1-\frac{1}{n^2}\,\frac{b}{a+b}\right)\theta. \quad (2)$$

But $\dfrac{v}{n}$ is the velocity of light in the stationary medium; the coefficient of θ is therefore the factor
$$x=\frac{n^2-1}{n^2}+\frac{1}{n^2}\,\frac{a}{a+b}. \quad (3)$$

It seems probable that this expression is more exact than Fresnel's; for when the particles of the moving medium are in actual contact, then the light must be accelerated by the full value of θ; that is the factor must be 1, whereas $\dfrac{n^2-1}{n^2}$ can

Fresnel's statement amounts then to saying that the ether within a moving body remains stationary with the exception of the portions which are condensed around the particles. If this condensed atmosphere be insisted upon, every particle with its atmosphere may be regarded as a single body, and then the statement is, simply, that the ether is entirely unaffected by the motion of the matter which it permeates.

It will be recalled that Fizeau* divided a pencil of light, issuing from a slit placed in the focus of a lens, into two parallel beams. These passed through two parallel tubes and then fell upon a second lens and were re-united at its focus where they fell upon a plane mirror. Here the rays crossed and were returned each through the other tube, and would again be brought to a focus by the first lens, on the slit, but for a plane parallel glass which reflected part of the light to a point where it could be examined by a lens.

At this point vertical interference fringes would be formed, the bright central fringe corresponding to equal paths. If now the medium is put in motion in opposite directions in the two tubes, and the velocity of light is affected by this motion, the two pencils will be affected in opposite ways, one being retarded and the other accelerated; hence the central fringe would be displaced and a simple calculation would show whether this displacement corresponds with the acceleration required by theory or not.

Notwithstanding the ingenuity displayed in this remarkable contrivance, which is apparently so admirably adopted for eliminating accidental displacement of the fringes by extraneous causes, there seems to be a general doubt concerning the results obtained, or at any rate the interpretation of these results given by Fizeau.

never be 1. The above expression, however gives this result when the particles are in contact—for then $b=0$ and $x=\frac{n^2-1}{n^2}+\frac{1}{n^2}=1$.

Resuming equation (1) and putting $a+b=l$ we find $(n-1)l=(\mu-1)a$. But for the same substance μ and a are probably constant or nearly so; hence $(n-1)l$ is constant.

But Clausius has shown that $l=\kappa\frac{\sigma}{\rho}a$, where κ is a constant, σ the density of the molecule; ρ, that of the substance; and a, the diameter of the "sphere of action." σ and a are probably nearly constant, hence we have finally $\frac{n-1}{\rho}=$constant.

Curiously enough, there seems to be a tendency towards constancy in the product $(n-1)l$ for *different* substances. In the case of 25 gases and vapors whose index of refraction and "free path" are both known, the average difference from the mean value of $(n-1)l$ was less than 20 per cent. though the factors varied in the proportion of one to thirteen; and if from this list the last nine vapors (about which there is some uncertainty) are excluded. the average difference is reduced to 10 per cent.

* Ann. de Ch. et de Ph., III. lvii, p. 385, 1859.

This, together with the fundamental importance of the work must be our excuse for its repetition. It may be mentioned that we have tried to obtain formulated objections to these experiments but without success. The following are the only points which have occurred to us as being susceptible of improvement.

1st. The elimination of accidental displacement of the fringes by deformation of the glass ends of the tubes, or unsymmetrical variations of density of the liquid, etc., depends on the assumption that the two pencils have traveled over identical (not merely equivalent) paths. That this is not the case was proven by experiment; for when a piece of plate glass was placed in front of one of the pencils and slightly inclined, the fringes were displaced.

2d. The arrangement for producing the motion of the medium necessitated very rapid observation—for the maximum velocity lasted but an instant.

3d. The tubes being of necessity of small diameter and only their central portion being available (since the velocity diminishes rapidly toward the walls) involved considerable loss of light—which, having to pass through a slit was already faint.

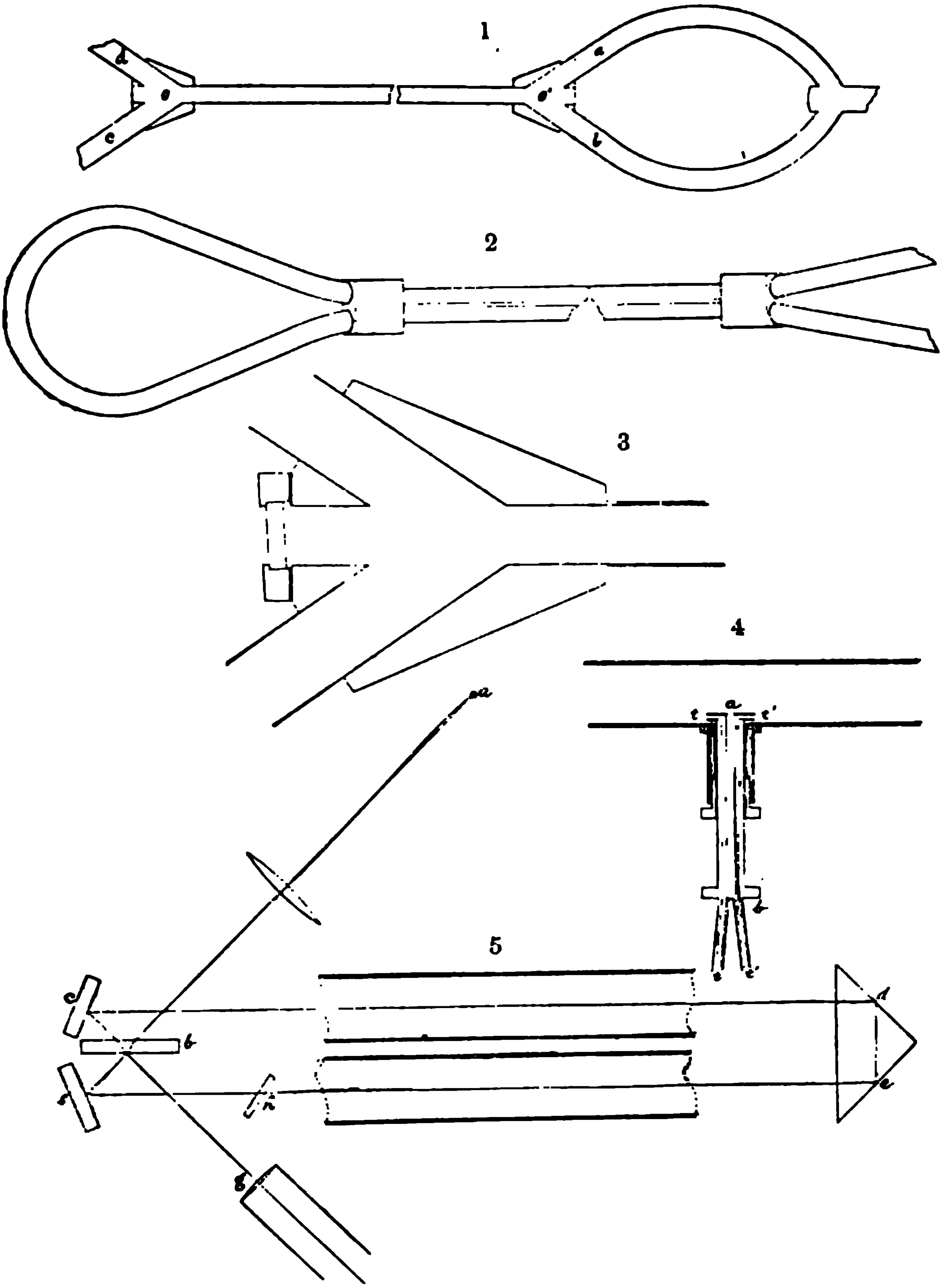
4th. The maximum velocity (in the center of the tube) should be found in terms of the mean velocity. (Fizeau confessedly but guesses at this ratio.)

These are the suggestions which determined the form of apparatus adopted, a description of which follows:

The Refractometer.—After a number of trials, the following form was devised and proved very satisfactory. Light from a source at a (fig. 5) falls on a half silvered surface b, where it divides; one part following the path $bcdefbg$ and the other the path $bfedcbg$. This arrangement has the following advantages: 1st, it permits the use of an extended source of light, as a gas flame; 2d, it allows any distance between the tubes which may be desired; 3d, it was tried by a preliminary experiment, by placing an inclined plate of glass at h. The only effect was either to alter the width of the fringes, or to alter their inclination; *but in no case was the center of the central white fringe affected.* Even holding a lighted match in the path had no effect on this point.

The tubes containing the fluid were of brass, 28^{mm} internal diameter; and, in the first series of experiments, a little over 3 meters in length, and in the second series, a little more than 6 meters. The ends of these tubes were closed with plane parallel plates of glass which were not exactly at right angles but slightly inclined so as to reflect the light below the telescope, which would otherwise be superposed on that which passed through the tubes. The tubes were mounted on a

wooden support entirely disconnected from the refractometer which was mounted on brick piers.



EXPLANATION OF FIGURES.

FIG. 1.—Vertical section through tubes. FIG. 2.—Plan of tubes. FIG. 3.—One end of tubes, showing glass plate inclined to axis. FIG. 4.—Gauge for velocity at different points. FIG. 5.—Plan of refractometer.

The flow of water was obtained by filling a tank four feet in diameter and three feet high, placed in the attic, about 23 meters above the apparatus, with which it was connected by a three inch pipe. The latter branched into two parts, and each

branch again into two; the two pairs being joined each to one of the tubes. The branches were provided with large valves, by turning which the current was made to flow in either direction through the tubes and into a large tank, from which it was afterward pumped up to the upper tank again. The flow lasted about three minutes, which gave time for a number of observations, with the flow in alternating directions.

Method of observation.—In the first series of observations a single wire micrometer was used in the eyepiece of the observing telescope, but afterward a double wire micrometer was employed. The tubes being filled with distilled water, the light from an electric lamp was directed toward the central glass of the refractometer and the latter adjusted by screws till the light passed centrally down both tubes, and then the right angled prism at the further end adjusted till the light returned and was reflected into the telescope, where generally two images were observed. These were made to coincide, and the fringes at once appeared. They could then be altered in width or direction by the screws, till the best result was obtained. A slight motion of one of the mirrors produced an inclination of the fringes, and the horizontal wire of the micrometer was placed at the *portion of the fringes which remained fixed*, notwithstanding the movement of the mirror. This adjustment was frequently verified, and as long as it was true, no motion of the tubes or distortion of the glasses could have any effect on the measurements. During this adjustment it was found convenient to have a slow current of water, to avoid distortions on account of unequal density.

The signal being given the current was turned on, and the micrometer lines set, one on each of the two dark bands on either side of the central bright fringe, and the readings noted. The difference between them gave the width of the fringe, and their mean, the position of the center of the central white fringe. This being verified the signal was given to reverse the current; when the fringes were displaced, and the same measurements taken; and this was continued till the water was all out of the upper tank. Following is a specimen of one such set of observations.

No. 63.

Direction of current.	+		−	
Micrometer wire.	*l.*	*r.*	*l.*	*r.*
	11	34	80	93
	13	35	71	88
	10	40	73	90
	13	38	67	92
	14	40	65	89
	10	35	61	94
Means	11·8	37·0	69·5	91·0

Width of fringe...........	48·8	60·5
Mean width..............		54·6 + (3·0 = index error)
Displacement	57·7	46·0
Mean displacement		51·8

$$\Delta=\frac{51\cdot8}{57\cdot6}=\cdot899.$$

(Long tube, vertical fringes, full current.)

Velocity of water.—The velocity of the water in the tubes was found by noting the time required to fill a measured volume in the tank, and multiplying by the ratio of areas of tank and tube. This gave the mean velocity. In order to find from this the maximum velocity in the axis of the tube the curve of velocities for different radii had to be determined. This was done as follows: a tight fitting piston *ab* (fig. 4) containing two small tubes *tt*, *t, t,* was introduced into the tube containing the water. The ends of the tubes were bent at right angles in opposite ways, so that when the water was in motion the pressure would be greater in one than in the other. The other ends of the small tubes were connected to a U tube containing mercury, the difference in level of which measured the pressure. The pressures were transformed into velocities by measuring the velocity corresponding to a number of pressures. Following is the table of results:—

Pressures.	Velocities.	$\frac{v}{\sqrt{p}}$
26	393	77·1
108	804	77·1
190	1060	76·9
240	1190	76·8

It is seen from the approximate constancy of the last column that within limits of error of reading, the square roots of the readings of the pressure gauge are proportional to the velocities.

To find the curve of velocities along a diameter of the tube, the piston was moved through measured distances, and the corresponding pressures noted. The diameter of the tube was about 28^{mm}, while that of the small tubes of the gauge was but 2^{mm}, so that the disturbance of the velocity by these latter was small except very close to the walls of the tube. The portion of the piston which projected into the tube was made as thin as possible, but its effect was quite noticeable in altering the symmetry of the curve.

In all, five sets of observations were taken, each with a different current. These being reduced to a common velocity all gave very concordant results, the mean being as follows: x=distance from the axis in terms of radius; v=corresponding velocity in terms of the maximum.

x.	v.
0·00	1·000
·20	·993
·40	·974
·60	·929
·80	·847
·90	·761
·95	·671
1·00	·000

The curve constructed with these numbers coincides almost perfectly with the curve

$$v=(1-x^2)^{.165}.$$

The total flow is therefore $2\pi\int_0^1(1-x^2)^{.165}xdx=\frac{\pi}{1\cdot165}$. The area of the tube being π, the mean velocity $=\frac{1}{1.165}$ of the maximum; or the maximum velocity is 1·165 times the mean. This, then, is the number by which the velocity, found by timing the flow, must be multiplied to give the actual velocity in the axis of the tube.

Formula.

Let l be the length of the part of the liquid column which is in motion.

u = velocity of light in the stationary liquid.
v = velocity of light in vacuo.
θ = velocity of the liquid in the axis of tube.
θx = acceleration of the light.

The difference in the time required for the two pencils of light to pass through the liquid will be $\frac{l}{u-\theta x}-\frac{l}{u+\theta x}=\frac{2l\theta x}{u^2}$ very nearly. If Δ is the double distance traveled in this time in air, in terms of λ, the wave-length, then

$$\Delta=\frac{4l\theta n^2x}{\lambda v}\text{ whence }x=\frac{\lambda v}{4ln^2\theta}\Delta.$$

λ was taken as ·00057 cm.
v = 30000000000 cm.
n^2 = 1·78.

The length l was obtained as follows: The stream entered each tube by two tubes a, b (figs. 1, 2) and left by two similar ones d, c. The beginning of the column was taken as the intersection, o, of the axes of a and b, and the end, as the intersection, o', of the axes of d and c. Thus $l=oo'$. Δ is found by observing the displacement of the fringes; since a displacement of one whole fringe corresponds to a difference of path of one whole wave-length.

Observations of the double displacement Δ.

1st Series. $l = 3{\cdot}022$ meters.
$\theta = 8{\cdot}72$ meters per second.
Δ = double displacement; w = weight of observation.

Δ.	w.	Δ.	w.	Δ.	w.	Δ.	w.
.510	1·9	·521	0·9	·529	0·6	·515	2·5
·508	1·6	·515	·9	·474	2·0	·525	2·7
·504	1·7	·575	·6	·508	1·4	·480	·8
·473	1·4	·538	2·1	·531	·8	·493	10·6
·557	·4	·577	·6	·500	5	·348	2·8
·425	·6	·464	1·7	·478	·6	·399	5·7
·560	2·8	·515	1·2	·499	1·0	·482	2·1
·544	·1	·460	·4	·558	·4	·472	2·0
·521	·1	·510	·5	·509	2·0	·490	·8
·575	·1	·504	·5	·470	2·1		

2d Series. $l = 6{\cdot}151$, $\theta = 7{\cdot}65$.

Δ.	w.	Δ.	w.	Δ.	w.	Δ.	w.
·789	4·9	·891	1·7	·909	1·0	·882	6·6
·780	3·5	·883	2·5	·899	1·7	·908	5·9
·840	4·6	·852	11·1	·832	4·3	·965	2·0
·633	1·1	·863	1·5	·837	2·1	·967	3·3
·876	7·3	·843	1·1	·848	1·9		
·956	3·6	·820	3·4	·877	4·7		

3d Series. $l = 6{\cdot}151$, $\theta = 5{\cdot}67$.

Δ.	w.	Δ.	w.	Δ.	w.	Δ.	w.
·640	4·4	·626	11·9	·636	3·1	·619	6·5

If these results be reduced to what they would be if the tube were 10^{m} long and the velocity 1^{m} per second, they would be as follows:

Series.	Δ.
1	·1858
2	·1838
3	·1800

The final weighted value of Δ for all observations is Δ = ·1840. From this, by substitution in the formula, we get

$$x = {\cdot}434 \text{ with a possible error of } \pm{\cdot}02.$$

$$\frac{n^2-1}{n^2} = {\cdot}437.$$

The experiment was also tried with air moving with a velocity of 25 meters per second. The displacement was about $\frac{1}{100}$ of a fringe; a quantity smaller than the probable error of observation. The value calculated from $\frac{n^2-1}{n^2}$ would be ·0036.

It is apparent that these results are the same for a long or short tube, or for great or moderate velocities. The result was also found to be unaffected by changing the azimuth of the fringes to 90°, 180° or 270°. It seems extremely improbable that this could be the case if there were any serious constant error due to distortions, etc.

The result of this work is therefore that the result announced by Fizeau is essentially correct; and that *the luminiferous ether is entirely unaffected by the motion of the matter which it permeates.*

Art. XXXVII.—*Note on the Structure of Tempered Steel;* by C. Barus and V. Strouhal.

In view of the experiments on the structure of steel by Dr. Hennig* now in progress in Professor Kohlrausch's laboratory, we avail ourselves of the permission of the Director of the Geological Survey and of the Editors of this Journal, to insert a brief but typical example of our own results here. The complete paper will appear in Bulletin No. 35 of the Geological Survey, now in the hands of the Public Printer.

The steel cylinder (length 6 cm., diameter 3 cm., weight 332 g.) to which the data refer was quenched glass-hard in the ordinary way. The consecutive cylindrical shells were then removed by galvanic solution, and the necessary measurements made to determine the density of each.

Let Δ be the density (0° C.) of the consecutive cores. Let R, ϑ, δ, be the mean radius, thickness and density, respectively, of the consecutive shells. Then if the *n*th core be left after the removal of *n* shells, the table gives the digest in question.

Shell or core No.	Δ.	R.	ϑ.	δ.	Remarks.
0	7·8337	---	---	----	Before quenching.
0	7·7744	---	---	----	After quenching.
1	7·7734	1·49	0·02	7·807	
2	7·7727	1·47	0·03	7·783	
3	7·7742	1·43	0·03	7·739	
4	7·7734	1·40	0 03	7·794	
5	7·7750	1·37	0·03	7·733	
6	7·7784	1·33	0·05	7·737	
7	7·7813	1·28	0·05	7·743	
8	7·7817	1·23	0·05	7·776	
9	7·7841	1·19	0·03	7·735	
10	7·7869	1·15	0·05	7·751	
11	7·7894	1·10	0·05	7·762	
12	7·7919	1·05	0·05	7·764	
13	7·7911	1·00	0·05	7·800	
14	7·7937	0·96	0·04	7·760	
15	7·7979	0·92	0·04	7·745	
16	7·7999	0·88	0·04	7·776	
17	7·8017	0·84	0·04	7·781	
18	7·8013	0·80	0·05	7·805	Core perceptibly fileable.
19	7·8027	0·75	0 05	7·792	
20	7·8009	0·69	0·07	7·811	

Washington–Prague, April, 1886.

* Wied. Ann., xxvii, 351, 1886.

ART. XXXVIII.—*Brookite from Magnet Cove, Arkansas;* by SAMUEL L. PENFIELD.

FINDING in the collection of Professor Geo. J. Brush a very beautiful crystal of brookite from Magnet Cove, which differs very much in habit from the ordinary crystals which I have seen, I thought it would be of interest to give not only a description of it, but also to figure and describe some of the forms which are common at the locality. The crystals are of the variety called Arkansite by C. U. Shepard,* and as far as I can learn very little has been written concerning them in our American journals. The common forms, corresponding to figures 1 and 2 of this article have been figured and fully described by G. vom Rath,† together with the pseudomorphs of rutile after brookite which occur at the locality. My examination has been confined to cabinet specimens in the collection of Professor Geo. J. Brush and the Yale College cabinet, and nothing can be said concerning the geological relations of the mineral. The crystals are frequently loose or are attached to smoky or milky quartz; they vary in size up to 2^{cm} in diameter. Although usually possessing polished faces, there are vicinal faces occurring with both prisms and pyramids which make accurate measurements with the goniometer difficult. The best measurements agree closely with those given by N. von Kokscharow.‡ The observed forms are:

e, 122, $1\text{-}\breve{2}$	*a*, 100, $i\text{-}\bar{\imath}$
z, 112, $\frac{1}{2}$	*m*, 110, *I*
χ, 124, $\frac{1}{2}\text{-}\breve{2}$	*t*, 021, $2\text{-}\breve{\imath}$

Of these forms, *e* is the most common, occurring frequently alone, usually, however, in combination with *m*. This latter combination is especially interesting when the prism is of such a size that it meets the four planes of the pyramid at the extremity of the *b* axis, forming there a solid angle of six faces; fig. 1. This combination is very common and appears like a doubly terminated hexagonal pyramid. The brachydiagonal pole edge of *e* is inclined 60° 42′ to the vertical axis, so that the projection of the six faces upon the brachypinacoid would be almost a perfect hexagon. As a rule, the faces of the prism vary in lustre from the pyramid and the frequent truncation of the vertical edge of *m* by the macropinacoid *a* serves as a ready means of orientation. The next most frequently occurring pyramid is *z*, which usually occurs beveling the brachydiagonal pole edge of *e*; fig. 2, showing also the prism *m*, a very common combination. The brachydome *t* is not so common as the above

* This Journal, II. ii, 250.

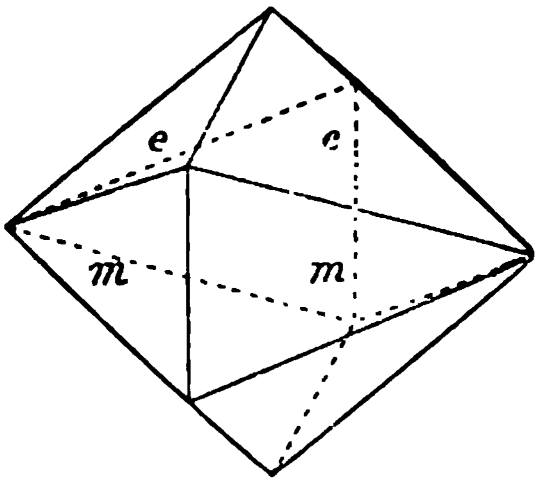
† Pogg. Ann., clviii, p. 407.

‡ Materialien zur Mineralogie Russlands, i, 61.

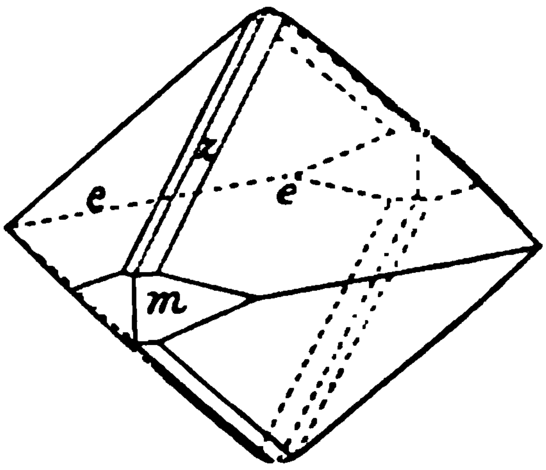
mentioned forms and usually appears with very small faces. One hand specimen of a very much decomposed siliceous rock contained a great number of small lustrous crystals about 2^{mm} in diameter, which show a very large development of *t*, fig. 3, but I have seen no large crystals with this habit. The macropinacoid *a* appears very frequently, but seldom largely developed.

The crystal which first attracted my attention is about 7^{mm} in its greatest diameter with very lustrous faces and symmetrical development; it is only a fragment. It shows all of the forms mentioned above with the addition of χ, which bevels the macrodiagonal pole edge of *z*. χ is a rare pyramid in this

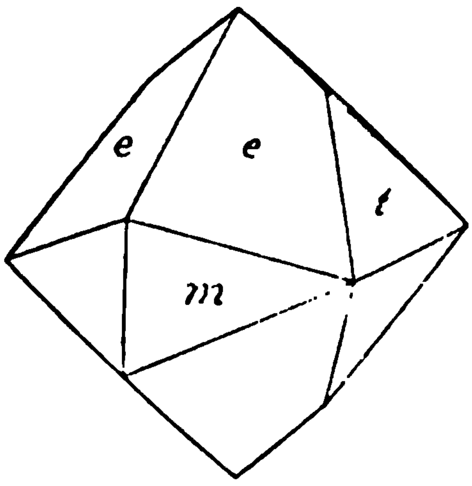
1.



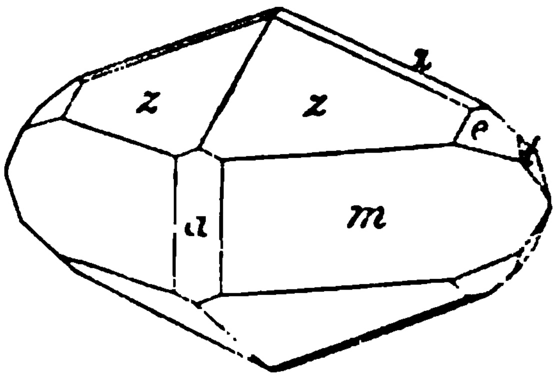
2.



3.



4.



species, and was first identified by von Leuchtenberg* on crystals from the Urals. The planes are arranged as in fig. 4. It will be noticed that the prominent pyramid is here *z*, while *e* is very subordinate. I have been able to find no duplicate of this crystal. Except the large rough crystals which are wholly changed into rutile, and which have the habit shown in fig. 4, only with more prominent prismatic development; all that I have seen show the pyramid *e* largely developed. The two pyramids *z* and *e* might be mistaken for one another were it not for the prism *m* which serves for orientation.

The angles which were measured and served for the identification of the faces (on crystal shown in fig. 4) are given in the

* Materialien zur Mineralogie Russlands, vi, 204.

wing table, together with the corresponding angles taken Kokscharow.

			Kokscharow.
$e \wedge e$	$122 \wedge \bar{1}22$	44° 19½′	44° 23′
$z \wedge z$	$112 \wedge \bar{1}12$	53 37	53 48
	$11\bar{2} \wedge \bar{1}1\bar{2}$	53 42	53 48
	$112 \wedge 1\bar{1}2$	44 30	44 46
$\chi \wedge \chi$	$124 \wedge \bar{1}24$	28 39	28 28
	$12\bar{4} \wedge \bar{1}2\bar{4}$	28 41	28 28
$e \wedge z$	$122 \wedge 112$	17 3½	17 6
$m \wedge m$	$110 \wedge 1\bar{1}0$	80 6	80 10
	$110 \wedge \bar{1}10$	99 51½	99 50
$a \wedge m$	$100 \wedge 110$	40 4	40 5
$m \wedge z$	$110 \wedge 112$	53 40	53 45
	$110 \wedge 11\bar{2}$	53 40	53 45
$m \wedge t$	$110 \wedge 021$	55 18	55 19
	$\bar{1}10 \wedge 021$	55 19½	55 19

will be noticed that the angles agree closely with those ı by Kokscharow, and a consideration of those angles cal· ed to determine the monoclinic symmetry of the crystal, $m \wedge z$ and $m \wedge t$ give us no sufficient ground for assuming the crystallization is other than orthorhombic. The reflec- from the faces of these crystals are usually not very); those from the one shown in fig. 4 are, however, an ption. In this crystal vicinal faces lay in the prismatic making an angle of 0° 39′ with *m*, and with the front of the vicinal prism measuring 81° 22′. There is also a al pyramid inclined 0° 21′ to *z*, and in the zone *z*, *e*, the al faces being nearest to *e* and showing faint though ıct reflections.

ıe gravity of this crystal taken very carefully is 4·084.

ıeralogical Laboratory, Sheffield Scientific School, March 20, 1886.

SCIENTIFIC INTELLIGENCE.

I. Physics and Chemistry.

On the Critical Temperatures and Pressures of certain ›s.—Vincent and Chappuis have determined the critical eratures and pressures for two series of compound gases, the bers of each series differing from one another by CH_2. In ırst series were ammonia and the three methylamines; in the ıd, hydrogen chloride and the chlorides of methyl and ethyl. experiments were made in the Cailletet apparatus, the tubes ; filled with ammonia or hydrogen chloride by simple dis- ›ment. The other gases were previously liquefied, and were ıined in vessels connected with the laboratory tube by means three-way cock, leading to a mercury pump. The tube was ully exhausted and then the gas was allowed to enter. About

5 or 6 centimeters of this tube remained filled with the gas when the liquefying point was reached. A carefully compared Baudin thermometer was plunged in a cylinder of water enclosing the tube, the temperature of which could be altered at will. Careful regulation of the pressure enabled the phenomena of appearance and disappearance of the meniscus to be produced within 1°. For hydrogen chloride the critical temperature was found to be 51·5°, the critical pressure 96 atmospheres. Methyl chloride may be compressed to 200 atmospheres at 142° without the appearance of a meniscus; but at 141°, the liquid is distinctly seen. The critical temperature is then 141·5° and the pressure 73 atmospheres. Ethyl chloride has its critical point at 182·5° and at 54 atmospheres. Ammonia gas has a critical temperature of 131° and a pressure of 113 atmospheres; corresponding closely with the values obtained by Dewar, 130° and 115 atmospheres. The critical point observed for monomethylamine was 155°, for dimethylamine 163°, and for trimethylamine 160·5°; the corresponding pressures being 72, 56 and 41 atmospheres respectively. Comparing the above temperatures with each other, it appears that while they progressively increase with the molecular complexity, their differences diminish. Comparing them with the critical pressures, it will be noticed that they vary inversely as these pressures, the value $\frac{273+T}{P}$ increasing slowly as the size of the molecule increases; contrary to the results obtained by Dewar for the simpler gases in which both pressure and temperature increased together. His figures show that the ratio $\frac{273+T}{P}$ is nearly constant and has a mean value of 3·5. The values of the present paper are for hydrogen chloride and ammonia 3·4 and 3·5 respectively; while methyl chloride gives 5·7, ethyl chloride 8·4, monomethylamine 5·9, dimethylamine 7·9, and trimethylamine 10·5.—*J. Physique*, II, v, 58, February, 1886. G. F. B.

2. *On the Double Refraction produced by Metallic films.*—KUNDT, desiring to prepare transparent films for his investigations on the rotatory magnetic polarization of the metals, made use of the method of Wright* for this purpose; i. e., showering down the material forming the negative electrode upon a glass plate in an exhausted receiver. But when the films thus prepared were placed between two crossed Nicol prisms he was surprised to find them double refracting. This phenomenon was observed with platinum, palladium, gold, silver, iron and copper. If the cathode is placed perpendicularly to the glass plate the deposit is slightly conical; so that when placed between the two Nicols, in parallel light, a black cross is seen in a bright field, the arms of which correspond with the planes of polarization of the Nicols. Kundt has shown that this effect cannot be due to the conical form of the deposit, to a state of tension of the metallic film, nor

* This Journal, III, xiii, 49, Jan.; xiv, 169, Sept., 1877.

to strain in the glass. Since gold, silver and copper are generally considered isometric the above experiments would seem to prove that they may be dimorphous. This sort of crystalline arrangement of the metallic particles the author attributes to the fact that the cathode particles are directed by the electric discharge and these particles have therefore an electric orientation. If the metal is oxidized, the double refraction disappears. Moreover similar films electrolytically deposited are not doubly refractive. He has observed moreover that the color of a silver layer thus obtained is variable with the temperature of the electrode and with the nature of the gas in the receiver. If such a film showing a blue color be examined with a dichroscope, it will be observed to be strongly dichroic.—*Wied. Ann.*, II, xxvii, 59, January, 1886. G. F. B.

3. *On the continuous production of Oxygen by the action of Calcium hypochlorite upon Cobalt oxide.*—BIDET has modified and improved Rosenstiehl's apparatus for obtaining oxygen by the action of cobalt oxide upon a solution of calcium hypochlorite. The generating vessel is a three-necked Woulff's bottle, having a lateral tubulure at bottom. In this bottle the cobalt oxide is placed, the hypochlorite solution being poured upon it through the middle tubulure, and the evolved gas passing off through one of the lateral ones. The third tubulure carries a safety tube. The delivery tube branches, one part going to the combustion tube or other place where the oxygen is needed; the other, to a two-necked bottle of 5 or 6 liters capacity, which acts as a gasometer. The second neck of this bottle carries a tube passing to the bottom, which is connected with the water supply. A lower lateral tubulure carries a recurved tube which rises to the top of the bottle and delivers the overflow. If the cock on the first branch of the delivery tube is closed, the oxygen generated passes into the gasometer, forcing out the water. This gasometer thus acts as a regulator causing the current of oxygen to be perfectly steady; even while the hypochlorite solution is being changed, as it may be through the lower tubulure of the generating flask. —*Bull. Soc. Chim.*, II, xlv, 81, January, 1886. G. F. B.

4. *On the direct fixation of Atmospheric Nitrogen by certain argillaceous Soils.*—During the past two years, BERTHELOT has conducted a set of experiments at the agricultural station of Meudon, with a view to determine quantitatively the action of argillaceous soils in fixing atmospheric nitrogen, in virtue of the microscopic organisms which they contain. The experiments were arranged in five series, carried on simultaneously, and necessitating more than 500 analyses. The soil in the first series was preserved in a closed room; in the second, in the open field under shelter; in the third, on the top of a tower 28 meters high, without shelter; in the fourth, in hermetically closed flasks; and in the fifth it was sterilized. After giving in detail the results of the experiments, the author concludes that they establish the fact that the soils examined, both sandy and argillaceous, possess the

property of slowly fixing free atmospheric nitrogen. This property is independent of nitrification as well as of ammoniacal condensation. And since the compounds formed are complex and insoluble amides of the character of those existing in living animals, it must be attributed to the action of living organisms. It is not manifested in winter, but is operative throughout the season of active vegetative growth. A temperature of 100° destroys it. It goes on as well in a closed vessel as in contact with the atmosphere; as well in the free air at the top of a tower as under cover in the vicinity of the soil covered with vegetation, or within a closed room in the interior of a building. It takes place in the dark though less actively than in the light. The figures obtained show that the amount of nitrogen which would be fixed by one hectare of surface would be, during a single season, for a yellow sand 20 kilograms; for a second sand 16 to 25 kilograms; for a clayey soil 32 kilograms.—*Bull. Soc. Chim.*, II, xlv, 121, February, 1886. G. F. B.

5. *On the Combustion of Carbon monoxide and of Hydrogen.*—In 1880, DIXON showed that a mixture of perfectly dry carbon monoxide and oxygen did not explode by the electric spark; but that even a minute trace of water or of a volatile body containing hydrogen, rendered the mixture inflammable. He accounted for this result by supposing the steam present to act as a carrier of oxygen, itself undergoing reduction thus: (1) $CO+H_2O=CO_2+H$ and (2) $(H_2)_2+O_2=(H_2O)_2$. To settle, if possible, the question as to the mode in which the steam acts he has now published a new series of experiments. He finds for example that small quantities of H_2O, H_2S, H_4C_2, H_2CO_2, H_3N, $H_{12}C_5$, HCl invariably cause the explosion, while SO_2, CS_2, CO_2, N_2O, C_2N_2 and CCl_4 do not. Hence he concludes that the steam does not act simply as a mere third body, but in virtue of its own peculiar chemical properties. He then studies the two reactions above given. As to the reduction of steam by carbon monoxide, that fact was established by Grove in 1846, when he discovered "the curious reversal of affinities." Dixon's experiments were conducted in a eudiometer containing two platinum coils. When carbon-monoxide and steam were heated to dull redness for six hours 5·2 volumes of CO were oxidized and 5·2 volumes of H produced, out of 100. At full redness for the same time 11·7 per cent and at bright redness 14·3 per cent of the CO was converted into CO_2. When CO_2 and H were subjected to the action of the hot platinum in the same tube, practically the same state of equilibrium was reached. If, however, the CO_2 formed in the first case, or the H_2O in the second, be removed as fast as produced, then the oxidation of the CO in the one and the reduction of the CO_2 in the other become complete. Induction sparks produce in both cases similar results. When the quantity of steam present is increased, the amount of CO oxidized is also increased. At a vapor tension of 13^{mm}, 3 per cent, at 102^{mm} 11·6 per cent and at 214^{mm} 21·4 per cent of hydrogen was formed. Having

thus shown the actual occurrence of the two reactions specified, the author goes on to discuss Traube's theory that hydrogen peroxide plays a part in the process; concluding that the facts do not support this hypothesis while they are satisfactorily explained by the theory he has offered.—*J. Chem. Soc.*, xlix, 94, Feb., 1886. G. F. B.

II. Geology and Natural History.

1. *Gas-Wells on Anticlinals.*—Prof. I. C. White,* of the Pennsylvania Geological Survey, has a paper on "The Geology of Natural Gas," in the Petroleum Age for March, in which, as in a paper in Science of last June, he presents evidence for the conclusion that the underground gas-accumulations of western Pennsylvania exist chiefly along very low anticlinals, and illustrates the subject with a map, giving the positions of the anticlinal axes and the gas-wells, from the maps of the Pennsylvania survey and partly his own examinations. The few apparent exceptions *among the large wells* he refers to the existence of transverse anticlinals (whose positions he also indicates on his map), these making an arching in a synclinal at the crossing. The synclinals are stated to be regions of subterranean waters and hence of comparatively little free or available gas, where there is any. He mentions, besides other facts, the case of a well recently located by him on the great Saltsburg axis, north of the town of Grapeville, which, on reaching into the "Murraysville sand" a few weeks ago, yielded an immense flow of dry gas. In contrast, a party from Greensburg put down a well *one mile east of the crest* of the same arch or anticlinal, at a locality where the dip had carried the rocks down 250 feet, and got an immense supply of water, and consequently what little gas came up was worthless. Mr. White states the fact from Illinois of recent observation (received by him from Mr. L. R. Curtiss, of that State): that along the low anticlinal in Illinois which extends from Ogle County S. 20° E. through Lasalle and Champaign Counties, and thence to Coles and Clark Counties in the southeastern part of the State, "natural gas can be traced in springs and well-borings for a distance of 160 miles; but it is more prevalent on the crowns of the cross anticlinal axes, as notably the case at Mendota.

The gas-wells at Erie and Fredonia, N. Y., have been instanced as exceptions to the general rule; but the supply of gas at these places is small, only 20,000 to 60,000 cubic feet daily, according to Professor Orton; while the great gas-wells deliver daily millions of cubic feet, some in the Murraysville field, it is reported, yielding thirty-three millions per day. "The first Murraysville well has been delivering more than twenty millions of cubic feet of gas daily for nearly ten years; and, with many other wells in close proximity, the volume has not been appreciably diminished." Moreover, Mr. White says that he finds, on recent examination, a

* The name J. C. White, on page 228 of this volume, should be I. C. White.

very low anticlinal at Erie and Fredonia parallel to Lake Erie. Ohio has afforded large gas-wells only along anticlinals; "Kentucky, Illinois and West Virginia tell the same story."

The subterranean gas-horizons in Washington County, Pa., are stated to be three: the *first*, 900 feet below the Pittsburg coal, the *second* 1,800 feet, the *third* 2,000 feet. The first is from the conglomerate No. XII, about 200 feet above the Subcarboniferous limestone, and the pressure of the gas seldom exceeds 300 pounds to the square inch. The horizon is that of the first Venango oil-sand, and is the "gas horizon par excellence of southwestern Pennsylvania"—being that of "Beaver, Allegheny, Butler and Westmoreland Counties," and of Wellsburg, West Virginia. The sand-rock is identified by Orton with the Berea grit of Ohio. The pressure in the Murraysville region (Westmoreland Co.) seldom exceeds 650 pounds to the square inch. The wells at Erie, which go down 600 to 700 feet, show a maximum pressure of only 40 to 50 pounds.

In another paper in the same number of the Petroleum Age, some of the advantages of gas for fuel are stated to be the following: ranges and furnaces of dwelling houses and factories may be lit up or extinguished in an instant; a steady heat is secured without attention; and no ash or flying dust accompanies the management. In one of the great factories of Pittsburg the twenty-four boilers that used to require the care of eighteen men day and night when coal was used, now need the care of only two. Storage of fuel is avoided; furnaces last longer; sulphur is not supplied from the fuel to injure the iron and steel produced. "There is one exception—it cannot be used in cupolas."

2. *Volcano of Barren Island in the Bay of Bengal.*—A detailed description of the Barren Island volcanic cone by Mr. F. R. Mallet, is contained in vol. xxi, Part 4 of the Memoirs of the Geological Survey of India. The position and features of the island have given it a prominent place in works on volcanos. This island has a diameter of two miles, the cone of about one.

The outer slopes of lava rise to a height of about 1100 feet, at an angle of nearly 25°, but are broken through to within 100 feet of the sea-level on the west side. The interior is a great amphitheater, in which stands the central cone, 1,000 feet at summit above tide level, whose sides have a surface of cinders or ash, and an even slope of 32°. This angle may have been reduced since the last ejection of cinders, by the rains which are heavy in this region. The accompanying figure is a reduced copy of one of the partially ideal sections illustrating Mr. Mallet's paper.

Rugged bare lava streams, having a scoriaceous crust, almost encircle the inner cone at its base; and projections of lava at two points high up the sides of the cone show that streams of lava have

descended from breaks in its sides. The appearances indicate comparatively recent action, perhaps within a century. The inner cone, according to Mr. Mallet, has certainly been made within the last 1800 years. No evidence of the asserted presence of the sea at any time within the limits of the amphitheater was found.

The heat below still gives rise to fumaroles and hot springs. Notwithstanding the "heavy tropical rains," the island has no surface streamlets, all the waters becoming subterranean. The water of the principal hot springs is brackish—containing over 200 grains of saline matter to the gallon.

The lava is mostly doleritic or basaltic, and much of it contains chrysolite. The formation of the amphitheater and the break in it on the west side are attributed to a "blowing away of the upper and central part of the cone by a great explosive eruption," like that of Krakatoa, Aug. 27, 1883.

The expression *explosive eruption*, which is above used and is common in accounts of violent volcanic action, is misleading. It seems to imply that in such eruptions, the top of the lava-made cone is projected off in the explosion, and that by this means came the great crater-area and its encircling walls; or that the ejections upward from the vent are the chief means of making the great cavity. But no one has yet reported the occurrence of large masses or slabs of the once stratified lavas from the lost part of the cone scattered over the remaining outside slopes, or shown that the *outflow of lavas* at the eruption may not have great undermining action.

Volcanic action in a crater, where there are liquid lavas, is largely a pseudo-boiling process; and the confined vapors of the enlarging bubbles, forcing an escape, are the chief projectile agency through which the more terrific explosive phenomena are produced, as well as the gentler of Kilauea-like type. Augmented activity means an augmented and more rapid escape of vapors through the viscid lavas; it means also augmented heat and a consequent extension of the region of liquid lavas, at and below the surface, by fusion of the adjoining solid lavas, and hence augmentation in explosive action. Cinder cones made about the vent in the quieter times may be destroyed by the projectile violence or become engulfed in the spreading region of fusion; and the rocks of the crater throat may be to some extent torn off and added to the ejectamenta. Finally, in the catastrophic eruption when the force from the rising vapors and from other conditions becomes greater than the mountain can withstand—a point often abruptly reached—the sides break and one or more fissures let out the liquid lavas. However explosive the action, the solid rock of the summit of the cone, while it may be more or less removed by the forces engaged, instead of being projected over the outer slopes, sinks down into the abyss so made. Thus a volcanic cone under the most formidable of explo-

sive eruptions may lose its head; but if so, it is by swallowing it, or simply by a collapse. The same is the process in quiet Kilauea: the solid lavas of the borders of the fiery region sink because the discharge of the liquid rock makes a void beneath them.

Vesuvius, through the viscidity of its lavas and its sources of vapors, has at times vast projectile force, and much is often attributed to its blowing powers; as in such sentences as this: "broke up and blew into the air the whole upper part of the cone."* But its processes are in the main, as in Kilauea, (1) filling, (2) discharging, (3) collapsing. It alternates in its conditions between a volcano with a profound crater and one with a top plain—the "altopiano" of Italian writers. The crater pit (sometimes 1000 feet deep) slowly fills by small ejections within it of lava and cinders.† Outflows of lavas from fissures in the mountain's side may occur at different stages in the filling; but usually the work goes on, with no great outbreak, until the cavity is full and a top-plain of solidified lavas, a mile or more in circuit, takes its place, with nothing left of the crater except the vent of a cinder-cone. If the fires now increase in activity, the plain may mostly disappear by the formation over it of a large cone (or two or more of them) about an area (or areas) of boiling lava throwing up lapilli, lava-masses, and bombs from the vent. Then, if an outbreak of the grander kind takes place, discharge upward of lava-fragments to great heights accompanies discharge outward-and-downward of lavas through opened fissures; and a collapse results owing to the loss by the upthrow and outflow ejections; consequently, what is left of the top-plain and its cones, with sometimes an upper portion of the great cone disappears by subsidence. Thus it happened at the eruption of May 31st, 1806; for Signor G. Zorda, speaking of it, says: "a considerable part of the summit fell into the volcanic abyss;"‡ and facts enough are reported to show that the same took place at the grander eruption of 1822. In the smaller eruptions of Vesuvus the "altopiano" often undergoes little change, because the undermining is not sufficient for more; and after a while cinder-eruptions may be resumed; consequently after such eruptions, as Scacchi observes, the height of Vesuvius may become increased.

The writer, at a visit to Vesuvius in July, 1834, found the summit a plain—the altopiano—with a small spurting cinder-cone near its center. A red heat existed 10 to 20 inches down in many fissures over the plain, and at one place a stream of lava, 4 to 5 feet wide, emerged and flowed off down the mountain.§ A month later, in August, a great eruption occurred, the lava

* Scrope on Volcanoes, p. 17.

† Well described by Scacchi for the interval 1840 to 1855. in his Eruzione Vesuviane del 1850 e 1855. Napoli. 1855.

‡ Relazione, etc., Napoli. 1806, in Scacchi's Memoir on Vesuvius, 1855, p. 15.

§ On the condition of Vesuvius in July, 1834, this Journal, xxvii, 281, 1835. For a sketch of the cone as it then appeared, see the writer's Text-book of Geology, p. 130.

›wing eastward far toward Torcigno. M. Abich, who was then, he reports, studying the volcano, after describing the top-plain ıd its cinder-cone as seen by him before the event, states that at e eruption, that platform of lava *subsided* and opened to view e interior of the large cone.*

Another great eruption took place in January of 1839, sending rth large streams of lava, and leaving a great funnel-shaped ater at top, 300 feet deep. The mode of origin of the depres-›n is not stated; but it may well have come chiefly from the scharge of lava, for three years of quiet intervened before the aptied mountain had again much activity in the crater.† The ıltopiano" was again the top of the filled crater before the close 1845, but no prominent eruption occurred before 1850, and this ft the summit-plain at the top occupied mostly by two very 'oad and low cones each with a deep crater.

The processes at Vesuvius are essentially those of Kilauea, and e variations in amount of subsidence about the active lava vents e similar. But in the crater of more liquid lavas, Kilauea, the scharge occasioning the subsidence or collapse is almost wholly at of outflowing lavas, the upward discharge by the projectile rce from rising vapors being small.

The lava eruptions are spoken of above as *through fissures*, ›cause the descriptions show this to be as much the fact at esuvius as at Kilauea. The forces engaged break the sides of e mountain along the upper or the lower slopes, or both, on one le or the other of the cone, and the lavas flow out, leaving dikes registers of the number and directions of the ejections. The 'erflows from the summit are insignificant compared with outflows ›m lower levels; the cup is full it is true; but nearly all the va is below the level of the top. Von Buch's observation that e lava of 1805, shot suddenly, before their eyes, from top to ›ttom of the cone in a single instant, or, as a calculator inter-'ets it, "many hundred feet in a few seconds," repeated by yell and others, is explicable only on the view that a fissure a series of fissures opened down the mountain and let out e lavas "in a single instant" from top to bottom. Fissures n be opened, as Kilauea shows, without an earthquake to nounce the event. J. D. D.

3. *Eruption at Kilauea, Hawaii, in March*, 1886.—Honolulu ›pers of the 15th of March ‡ report the sinking and disappear-ce of the lavas of Kilauea, implying, thereby, their discharge by me outlet. On the evening of Saturday, March 6th, the Old d New Lakes of liquid lavas in the great pit-crater, Kilauea, ›re unusually full and brilliantly active, as seen from the Vol-no House, on the northeast edge of the great pit; and an ac-

* Erlaut. Abbild. Vesuvius und Aetna, Berlin, 1837.

† Scacchi (loc. cit.) gives a sketch of the crater when in the quiet state, and ›ther showing its condition in October, 1843, after the filling of it had again gun.

‡ The editors are indebted for the papers to Mr. Alexander, Surveyor General the islands.

count by Mr. E. Finley states that the place of the path between the New Lake and Old Lake, called "the bridge," was at this time "swept away by an overflow of red hot lavas," which seems to imply that the solid lava making the bridge was melted away by the encroaching of the liquid lavas from one side or the other, owing to the increased heat. This condition continued until late that evening. After midnight, between 2 and 3 o'clock, the lavas of both lakes suddenly disappeared and the fires went out. At 7^h that morning, when the clouds had cleared away, it was discovered also that the bluffs of solid lavas that bordered the Old Lake (Halemaumau), part of which were 200 feet higher than the surface of the boiling lavas, had sunk into the depths below—the depths deserted by the liquid lavas. Besides this, the region of the "bridge" between the two lakes had subsided, so as to make one great chasm of the area of the two lakes. By the night of March 7th all was total darkness in the crater, "excepting a few small lights from previous flows;" and on the afternoon of March 8th, as one who had been down into the crater reported, the fires were to appearance wholly extinct, though hot vapors still came up; the site of the New Lake was a great hole 150 feet to bottom, and that of Halemaumau a much larger cavity 500 feet deep. In addition, at the time of the earthquakes, several rents were made outside of the crater of Kilauea; one on the road from the Volcano House to another pit-crater called Kilauea-Iki, and two about two miles from Kilauea on the Keauhou road (leading toward the steamboat landing). For many days after the disappearance of the lakes "large portions of the edge were continually falling into the terrible gulf with thundering sounds" that were attributed at first to earthquakes.

No outflows over the slopes of Kilauea above the sea-level are reported. There may have been a submarine discharge. All known eruptions of Kilauea have been similar in general character: a condition of unusual heat and activity in each case being followed by a sinking of the lavas in the crater attending a discharge (above the sea-level in some cases), and a subsidence also of more or less of the bordering solid lavas. The extent within Kilauea of the surface of activity in the spring of 1840, and of the consequent subsidence of solid lavas at the eruption, six months before the writer's visit to the region, has not since been equalled; for an area 12,000 feet in length and 3,000 feet in mean width then sunk down 400 feet; but alternations of activity and of discharge with subsidence of less extent, followed by quiet and a gradual increase in heat and activity of the lava, preparatory to a new discharge, have many times occurred. The discharge and subsidence are not premonitions of great activity, but results of fractures somewhere and an outflow, with a collapse, from which recovery is slow. J. D. D.

4. *Making deposits of the remains of birds, squirrels, and other small animals.*—Professor E. W. Hilgard, in a paper on the asphaltum deposits of California, published in Williams's

neral Resources of the United States for the years 1883 and 34, mentions (p. 940) that in Ventura County, thick mineral or pitch oozes or flows from the beds of the Sierra de Azufre, led also the Petroleum range, into the Santa Paula valley, d forms surface deposits, moving down the ravines, partly idifying into rock-like masses, and partly forming lazy streams the beds of rivulets. In the wet season these beds carry water, t during the dry and warm part of the year exhibit delusive lecting surfaces of shining tar, generally mingled with a little careous water, which serves to delude all kinds of living crea-es into the belief that they may there slake their thirst. Thus phers, moles, squirrels, rabbits, all kinds of birds from the buz-d and hawk to the canary, as well as all kinds of insects may found just caught or completely submerged in the pitiless cid mass, which rarely releases a victim once touched. The quent occurrence of bones of lambs and calves sometimes oves that even these larger animals are entrapped; and the man foot may not escape the grip without loss of boot or shoe.

5. *The history of Taconic investigation previous to the work Professor Emmons;* by J. D. Dana.—The following notes are m the opening part of an Address on Berkshire Geology, livered before the Berkshire Historical Society, at Pittsfield, ass., in February, 1885.

The earlier workers in this field were Professor Amos Eaton, Dr. ester Dewey, Professor Ebenezer Emmons and Professor Ed-rd Hitchcock. Three of the four were graduates of Williams llege; Eaton in 1799, Dewey in 1806, and Emmons in 1818.

Professor Eaton, after examinations, as he says, of the High-ds on the Hudson, the Catskill Mountains, the Green Moun-ns, and some other points, with old Kirwan as his text-book on ks and minerals, put himself, in 1816, under the instruction of ofessor Silliman, at New Haven, and heard two of his courses lectures on mineralogy and geology. In March of the next ar, the zealous naturalist, now doubly charged with enthusiasm his own reënforced with that of his eloquent teacher—began a urse of lectures at Williams College, with specimens supplied n by Professor Silliman and a collection made by Professor wey, then Professor of Mathematics and Natural Philosophy d Lecturer on Chemistry in the College; and "such was the l," says Mr. Eaton, "that an uncontrollable enthusiasm for tural History took possession of every mind, and other de-rtments of learning were, for a time, crowded out of college. e college authorities allowed twelve students each day (72 per ek), to devote their whole time to the collection of minerals, nts, etc., in lieu of all other exercises."

Mr. Eaton, while there, gathered specimens of rocks from all ections, through his students. He also made two tours from ston across Massachusetts; and by 1820 he had examined the ks along several sections between Massachusetts and the Hud-, besides making various excursions elsewhere—2,000 miles of ich, he says, were made on foot.

In 1817, Professor Eaton left Williamstown for Albany, leaving the special geological study of the region in Dr. Dewey's hands, and three years later he acknowledges (in his Index to the Geology of the United States, 1820), "the assistance for two or three years, of that very able and accurate naturalist, Professor Dewey of Williams College," and shows his appreciation of the knotty character of the region by the additional remark: "He resides at the very central spot of the most complicated difficulties, and never suffers any interesting fact to escape his notice."

In January, 1819, Dr. Dewey was ready with results, and published, in the first volume of this Journal (p. 337–345), a geological description of the Williamstown portion of the Taconic region. In 1820, in vol. ii of the same Journal (p. 246), this paper was followed by another on a "Geological section from the Taconic Range in Williamstown to the city of Troy." By the summer of 1824 he had much widened the range of his researches, as shown in the eighth volume of this Journal (pp. 1 to 60 and 240 to 244), in an article the "Geology of Western Massachusetts and a small part of the adjoining States," illustrated with a colored geological map embracing all Berkshire, the southern portion of Vermont, Canaan and Salisbury of Connecticut, and eastern New York to the Hudson.

The "Taconick Hills" first took their place in geological literature in his paper of 1819, in which (on p. 337) he mentions the Indian orthography of Taconic and gave the word its present shape. This first geological map of Berkshire, published in 1824, shows the north and south direction of the belts of limestone; the Taconic backbone of the region, consisting, as he had found, of "mica slate" and "argillite;" the "primitive limestone" to the east of the Taconic range, the "transition limestone," or less crystalline, to the west; the isolated ridges of quartzyte, and areas of mica schist and gneiss farther east; the "gray wacke" and slates farther west to the Hudson. Professor Dewey also observed the general eastward dip of the rocks. Following Eaton, he sought, by the terms "primitive," "transition," "gray-wacke," to bring the facts into parallelism with those of English and European geologists. Professor Dewey says, in his appendix to this paper in the same volume (p. 242), "*In Fishkill I found petrifactions in siliceous slate associated with argillite.*" This very important discovery has not since been verified; but probably will be, since Lower Silurian fossils have been recently found just north in the slate of Poughkeepsie, and many more in the neighboring Barnegat limestone.

It deserves mention that Dr. Dewey was enough of a chemist to use the science to great advantage in his geological work. By means of it he determined rightly the composition of the prevailing slaty rock of the Taconic range, and set forth his determinations repeatedly in his published papers. These slates were pronounced by Eaton and others *Talcose slates*, because, like talc—a magnesia mineral—they *felt greasy*. But in 1819 he said, "I

have been able to detect only a very minute quantity of magnesia in any specimens I have tried, but much alumina." Thereupon he, with good reason, called the rock "*very fine-grained mica slate.*" But the other geologists, including Emmons and Hitchcock, did not accept of his determination, and the error continued in the science of both America and Europe, for forty years and more. Dr. Dewey was a keen-eyed student of Nature, and New England geological science lost much by his leaving the field after having well passed its threshold.

Professor Ebenezer Emmons received his scientific inspiration from Professor Eaton, whose rousing lectures, at Williams College, he heard while in his Junior year. Under its influence he became one of the most active and faithful geologists of the country. He was a pupil in Professor Eaton's Rensselaer school, which was opened in Troy in 1824, and in 1826, the year of his graduation, published a small "Manual of Mineralogy and Geology," for the Rensselaer school. (This Manual was my first school book on the science while at a High-school in Utica, between the years 1827 and 1830, where another Rensselaer school graduate was our instructor in chemistry and natural history.) Like Professor Dewey he became an instructor in Williams College, entering upon his duties there, as a Professor of Natural History, in 1833, and then commenced his geological investigations.

6. *Fifth Annual Report of the U. S. Geological Survey*, 1883 to 1884; by J. W. Powell, Director. 470 pp. roy. 8vo, with many plates and other illustrations.—The report of the director, here presented, shows that a large amount of geological work is in progress under the survey and that all of it is of high order. The papers published with the report are the following: The topographical features of Lake shores, by G. K. Gilbert; Preliminary paper on an investigation of the Archæan formations of the Northwestern States by R. D. Irving; The requisite and qualifying conditions of Artesian wells, by T. C. Chamberlin; The gigantic mammals of the order Dinocerata, by O. C. Marsh; existing glaciers of the United States, by I. C. Russell; and a Sketch of Palæobotany, by L. F. Ward. The work of Professor Marsh on the Dinocerata has already been noticed at length in vol. xix (1885) of this Journal, and the report of Mr. Russell briefly in the current volume; and Professor Irving has a paper in vol. xix on the Archæan which bears on some of the points he here considers.

Professor Chamberlin's report, as its title implies, is a scientific review of the conditions favorable and unfavorable to success in Artesian borings, and has a direct reference to economical results. The discussion is based on a wide range of facts from a geological source and from past experiences in borings, and the explanations are accompanied by many illustrating figures. The report is therefore an excellent manual on the subject.

A new feature in artesian boring came to the writer's knowl-

edge last summer when at Lebanon Springs, at the western foot of the Taconic Range, in Columbia County, N. Y. In that vicinity, where the schistose rocks (hydromica schists) stand at a high angle, an artesian boring had been run into the hills nearly *horizontally* for three hundred feet, and a permanent flow obtained. A vertical boring at the same place would have been in all probability without success, as in most other regions of metamorphic rocks.

The paper on the *Topographical features of Lake shores*, by Professor Gilbert, treats of the character and origin of these features, and considers the physical questions as to the nature and effects of wave and current action in erosion, transportation and deposition. It takes up therefore the subject of water action over the earth's surface from a fundamental point of view, omitting the part consequent on tidal movements; and, under the action of water, that of ice, its frozen condition, is included. "Littoral erosion and the origin of the sea-cliff and wave-cut terrace" is first explained, then, "the process of littoral transportation, with its dependent features, the beach and the barrier, and finally the process of littoral deposition, resulting in the embankment with all its varied phases and the delta." Wave action from winds or currents, is considered at length as a question in physics, and its effects followed out as to methods, and as to results in the sculpturing of the shores; and then deposition is considered, its determining and modifying conditions, and results in beaches, bars and deltas. The formation of terraces of different kinds, and that of moraines, and other results of ice deposition are also considered under the head of "the discrimination of shore-features," and "the recognition of ancient shores." The Utah Great Salt Lake and the Lake Bonneville region has afforded Professor Gilbert many of his facts, but far from all. Besides plates illustrating this region, there are others giving admirable views from Lake Michigan, Lake Superior, Colorado, Montana and Idaho.

Mr. Ward's sketch of *Paleobotany* is mainly historical and treats of the discoveries hitherto made. In its review of discoverers it commences with Scheuchzer, whose Herbarium Diluvianum appeared at Zurich in 1709, and from him passes to Baron von Schlotheim, whose first publication on fossil plants appeared nearly a century later, in 1801; then speaks of Sternberg, Brongniart, Witham, Göppert, Corda, Geinitz, Binney, Unger, Schimper, Williamson, of Europe and Britain; and then of Lesquereux and Dawson, whose first publications appeared in 1845; of Heer and Bunbury, who published first in 1846, of Massolongo and Ettingshausen, 1850; of Newberry, 1853; Schenk of Leipsic, 1858; of Saporta, 1860; and of Carruthers, 1865. A review of the more important publications follows, and a consideration of the classification of plants, with the bearings on the subject of classification of the facts made known by paleontological discovery. The paper closes with tables giving the number of spe-

cies, or so-called species, found fossil in the successive geological formations, and of those now existing, with diagrams illustrating the progress of the several grand divisions.

The volume contains also a copy of the colored geological map of the United States by Mr. McGee, of the Survey, already noticed in this Journal.

7. *The work of the International Congress of Geologists and of its Committees;* published by the American Committee, under the direction of Dr. PERSIFOR FRAZER, Secretary. 110 pp. 8vo, 1886.—This pamphlet contains Dr. Frazer's report of the discussions at the Congress, together with a general notice of the meeting, extracts from the very valuable report of 147 pages published in England, by the English Committee, and from the reports of some of the European Committees. It also presents, on a folded plate, the scheme of colors for geological maps, proposed by the Congress and used on the geological map of Europe now in course of publication. Through the distribution of the scheme it is hoped that a general uniformity may be ultimately secured in the maps of all lands. Complete uniformity between the different nations as to geological terms or colors is not to be expected on account of existing differences among them in language, in rock formations and their unequal display, and in geological opinions based partly on differences of progress in some of the divisions of the science, and partially on national preferences.

Great credit is due to Dr. Frazer for his labors as Secretary of the American Committee and as editor of the report now issued. Those wishing copies of the Report should address Dr. Frazer, in Philadelphia, and enclose fifty cents—the cost of publication.

8. *Mastodon, Llama, etc., from Florida.*—Professor LEIDY has reported (Proc. Philad. Acad. N. Sci., 1886, 11) the occurrence of bones of Mastodon, Auchenia (llama), Hippotherium, Rhinoceros and Megatherium, near Archer, Florida. Some of the mastodon bones are very near *M. angustidens* in species, and are named *M.* (*Trilophodon*) *Floridanus.* Three species of llama are supposed to be indicated and the names proposed for them are *A. major*, *A. minor*, and *A. minimus.*

9. *Fossil leaves in Staten Island and Long Island Clay beds.* (Trans. N. Y. Acad. Sci., iii, 30).—Leaves in clay beds are here reported by Dr. N. L. Britton from the southern end of Staten Island and from Glen Cove, Long Island, the beds at both places apparently of the same age with the plant-bearing clay beds of the Middle Cretaceous in New Jersey. Dr. J. S. Newberry stated that he had already exhibited similar specimens from Williamsburg, Lloyd's Neck and Glen Cove, Long Island, including large numbers of angiospermous leaves, which were probably of the age of the Raritan clays.

10. *Systematische Ubersicht der fossiler Myriapoden, Arachnoideen und Insekten*, von S. H. SCUDDER. (Verlag von R. Oldenbourg, München u. Leipzig).—This important, well illustrated review of fossil myriapods, arachnoids and insects, covers

pages 721 to 831 of Zittel's Handbuch der Palæontologie, I Abtheilung, Palæozoologie, BD. II, and bears the date of 1885.

11. *On the Higher Devonian Faunas of Ontario Co., N. Y.;* by J. M. CLARKE. 80 pp. 8vo, with three plates. Bull. U. S. Geol. Survey, No. 16. Washington, 1885.—Among the fossils from the Genesee shales, are *Dinichthys Newberryi* Clarke, and *Palæoniscus Devonicus* Clarke; from beds above, called Naples beds, *Palæoniscus*, with a fish spine referred to *Pristacanthus*. (The *Dinichthys* is near, though distinct from, the species described by G. N. S. Ringueberg from the Portage Group on Lake Erie).

The Naples beds include the lower part of the series referred by Hall to the Portage, namely, the Cashaqua shales and Gardeau shales, which, according to Mr. Clarke, belong with the Genesee shales in fauna; while the rest of the Portage series, the Portage sandstone, he would transfer to the Chemung group.

Mr. Clarke describes a "Goniatite concretionary layer," as occurring at an elevation of about 150 feet above the top of the transition shales. The rock contains much pyrite, has a thickness of eight inches to a foot, and is overlaid by four feet of soft shales abounding in concretions; and nowhere above the Marcellus shales (of the lower Middle Devonian) are Goniatites so abundant as here. The deposit is compared in its characters and the abundance of Goniatites to the Kramenzelkalk or Goniatitenschichten of the Rhine Provinces and Westphalia. Hall's species *Goniatites Patersoni*, *G. discoideus* and *G. sinuosus* are in comparatively great abundance and generally have served as nuclei for the concretionary masses.

A number of new species are described from the beds. After the descriptions follows a list of all the known species of the several divisions of the Genesee, Portage and Chemung groups from Ontario County.

12. *Fossil Ostracoda from Colorado.*—Professor T. RUPERT JONES has studied the Ostracoda of the Jurassic Atlantosaurus beds, near Cañon City, from specimens of the rock sent him by Dr. C. A. White, of the U. S. Geological Survey, and described and figured seven new species in the "Geological Magazine" for April.

13. *The Tripyramid Slides of* 1885 (Appalachia, iv, No. 3, 1886), p. 177).—In this paper Mr. A. A. BUTLER, after describing the effects of the slides in 1885 of Mt. Tripyramid in the White Mountains considers the facts that determine the occurrence of slides, and among these mentions as "one of the secondary factors, the preparatory work done by underground streams," in wearing and making channels over the surface of the underlying rocks; and observes that this is often promoted by the laying bare of the rocks for short distances by small or incipient slides. The question as to where a slide begins, whether at the top or at the bottom, he answers by saying, with sustaining reasons, at neither, but at some distance above the bottom. The Tripyramidal slide occurred on an average slope of about thirty-four degrees.

s width was 350 feet at the top; over 300, in general, below; rer 400 where it turned at a right angle and entered the brook; s length on the mountain was half a mile; to the foot of the elta made by it nearly two miles.

14. *Titanichthys and Dinichthys from the Devonian of Ohio*, Trans. N. Y. Acad. Sci., v, No. 2).—The Titanichthys, which r. Newberry here describes, is a gigantic fish, much larger than inichthys, the cranium being four feet broad (that of the largest inichthys being three feet), to which he gives the specific name *! Agassizii*. It is from the Huron Shale, bordering Rocky River, few miles west of Cleveland. Besides *Dinichthys Hertzeri*, Dr. ewberry mentions the discovery of *D. Terrelli* in the valleys of lack and Vermillion Rivers, and two smaller species, *D. minor* id *D. corrugatus*; also a fourth, *D. Gouldii*, at the Rocky River cality. The last is remarkable for the size of the eye and for a ries of sclerotic plates, four inches in diameter, around the eye, ke those in Ichthyosaurus. He mentions that *Coccosteus* has cently been proved by Professor von Kœnen, of Göttingen, to ave a bony ring round the eye. The same paper contains notes i his *Diplognathus mirabilis*, also of the Dinichthys family.

15. *Catalogue of the Fossil Mammalia in the British Museum*. art II, containing the Order Ungulata, Sub-order Artiodactyla; y R. LYDEKKER, F.G.S., etc. 320 pp. 8vo. London: 1885.—his catalogue contains many descriptive notes on the species and ecimens in the collections of the British Museum, numbers of iem type specimens, which make it much more than a catalogue.

16. *Discussion on Climate and Cosmology*; by JAMES CROLL, L.D., F.R.S. 328 pp. 8vo. Edinburgh, 1885.—Dr. Croll's ecent papers in this Journal make it only necessary to announce ie publication of this new volume, in which the views in those apers are mostly embodied.

17. *Allgemeine und chemische Geologie von* JUSTUS ROTH. [Band, Zweite Abtheilung.—The continuation (see vol. vii, 493) ow issued of this important work carries the description of rocks irough the "younger eruptive rocks," which are discussed under ie heads sanidine rocks (1), the leucite and nepheline (2 and 3), nd the plagioclase rocks.

18. *On a crystalline slag having the composition of Fayalite*; y EDO CLAASSEN (communicated).—The slag under examination as an iron-black to steel-gray color and a metallic luster. Its ardness is 5·5, its specific gravity 4·211. It is strongly magetic, and gelatinizes with strong hydrochloric acid, though not ompletely. Cavities in the slag occasionally contain prismatic rystals, showing the forms $i\text{-}\bar{2}$, $2\text{-}\breve{i}$, $i\text{-}\breve{i}$ (Dana's Mineralogy) and ffording angles which agree closely with those of chrysolite. 'hree analyses were made, one of which yielded the following esults:

SiO_2	FeO	Al_2O_3	MnO	CaO	MgO	K_2O	Na_2O	S	
28·16	68·39	1·84	0·19	0·32	0·15	0·17	0·21	0·24	= 99·67

he sulphur is probably combined with iron as FeS; deducting

this, the analysis corresponds very closely to an iron unisilicate. The slag, therefore, has the composition as well as the form of the mineral fayalite, similar to other iron slags which have been described by Mitscherlich and others.

19. *Journal of the Trenton Natural History Society*, January, 1886, vol. i, No. 1, 22 pp. 8vo.—This first number of the Journal of this Society in New Jersey contains interesting notes on several geological and botanical subjects. The last is a paper by Dr. A. C. Stokes on Peridinium and other infusoria.

20. *Recent Notes from Botanische Zeitung.*—In the numbers for last January, Professor Hugo DeVries gives an account of his studies relative to the phenomena of aggregation in the tentacles of Drosera (see this Journal for last December). His conclusions may be thus summarized: All stimulants which heighten the activity of secretion by the glands in insectivorous plants bring about remarkable protoplasmic changes dependent on three factors. These are (1) an increase in the ordinary cyclosis of the protoplasm on the wall of the cell; (2) a division of the vacuole into very numerous minute portions which remain enclosed by the original film of the large vacuole; (3) a very remarkable diminution in size of these minute vacuoles, by which a part of their contents is expelled through their walls, and then, having chemical properties unlike those of the vacuolar contents left behind, this soon aggregates in the form of the well-known masses described by Darwin. After the stimulation has passed, the minute vacuoles become again confluent, the expelled contents resume their former dissolved condition, and pass into the large vacuolar space.

In the numbers for February, Arthur Meyer takes up the formation of starch granules in foliage leaves, noting the existence in assimilating leaves of the following substances: mannite, dulcite, glucose, cane-sugar and sinistrin (a body allied to inulin). Meyer's experiments appear to show that on withdrawal of leaves from light, there is, for a while, a steady diminution in the amount of the soluble substances above mentioned, and at the same time there is consolidation of these carbohydrates under the form of starch through the influence of the amyloplasts. G. L. G.

III. Astronomy.

1. *A Popular History of Astronomy during the Nineteenth Century*; by Agnes M. Clerke. 8vo. Edinburgh: A. & C. Black, 1885.—The aim of Miss Clerke is to present in a popular manner the discoveries that have been made in what she calls the "new Astronomy" since the time of Herschel. Mathematical theories, except in their more striking results, are excluded from consideration.

There is a charm in the history of any science, when the story is well told, which the science presented as a finished product does not possess, and Miss Clerke has told this story remarkably well. The book is intelligible to the ordinary thoughtful reader,

and yet a very large class of men engaged in other lines of science will find it not merely a popular history but also a valuable book of reference. The "materials have been derived, as a rule with very few exceptions, from the original authorities." References are given for nearly every important assertion, and a reader who has occasion to verify or who questions any statements is thus easily put in the way of examining them for himself.

In the very numerous cases where astronomers differ in their conclusions Miss Clerke has had no easy task. She has, we think, been very successful in most cases in choosing the right side, or else in holding an even balance between the opposing opinions. Occasionally, however, her success may be questioned. Respecting the large *vs.* small telescopes she says: "it seems clear that we have reached a turning-point in the history of telescopic improvement." At the time this was written she probably had not in hand the latest testimony of Dr. Vogel about the perfection of the images of the Vienna refractor, and certainly had not the recent testimony of Professor Young. From the fact that one observer with a 4½ inch glass sees details which another with an 18 inch glass cannot see, practical astronomers will not, we think, at once decide against the greater utility of the larger glass.

H. A. N.

2. *The Star-guide, a list of the most remarkable Celestial objects visible with small telescopes;* by LATIMER CLARK and HERBERT SADLER. Macmillan & Co. 1886.—A very convenient manual for the possessors of small telescopes. It gives catalogues of interesting celestial objects, of test objects, variable stars, lunar mountains and meteor radiants, in a form convenient for use.

3. *Photographic Study of Stellar Spectra.*—In accordance with the liberal provision of Mrs. Henry Draper, the study of stellar spectra by means of photography is to be carried forward at the Harvard Observatory as a memorial to her husband. In announcing the plan of this work, the Director, Professor E. C. Pickering, states that in order to keep the astronomical public informed of the progress made, specimens of the photographs will be gratuitously distributed from time to time, the first of which is nearly ready. It is desired that those immediately interested in the work express their desire to obtain copies, in order that the expense of reproduction may be limited as far as possible. Applications may be made to the Harvard College Observatory; a blank form of request is provided.

IV. MISCELLANEOUS SCIENTIFIC INTELLIGENCE.

1. *The Fisheries and Fishery Industries of the United States,* prepared through the co-operation of the Commissioner of Fisheries and the Superintendent of the Tenth Census, by GEORGE BROWN GOODE, Asst. Director U. S. National Museum, and a staff of associates. Section I, Natural History of useful Aquatic Animals, a volume of text in 4to of 896 pages, and a second volume of 277

plates.—This Report is a full account of the useful aquatic animals from both Natural History and industrial points of view and its objects are well carried out. Thirty-two pages and 11 plates are devoted to the whale, eighty-two pages and 12 plates to the seals and walrus, besides a map of the world (plate 24), showing their geographical distribution; and with like fulness, varying according to the importance of the species, the many kinds of edible, or otherwise useful, fishes are described, the squids, the common mollusks, such as the oysters, clams, mussels, etc.; the Crustaceans, as the lobster, crabs, prawns, the common starfish, etc.

This contribution to the great and important subject of the American Fisheries has been prepared under the supervision, and largely the labor, of Mr. Goode, and at the joint expense of the U. S. Census Office and the Smithsonian Institution. It is to be followed by other volumes on the Fishing Grounds, the Fishing Towns, the Fishery Industries, and related topics.

2. *Outlines for a Museum of Anatomy, prepared for the Bureau of Education*, by R. W. SHUFELDT. 66 pp. 8vo. Dept. of the Interior, Washington, 1885.—The author of this report urges the importance of making museums of anatomy museums of general structural zoology, and treats of the methods of forming them and of the classification that should be adopted. The discussion of the last topic occupies the most of the pages; and in the course of it, he illustrates the view that the true order of arrangement is that which best shows the successional order and relations of the groups and species, and advises as to the species in each group that are most illustrative in this and other respects, and which therefore should be preferred for a museum.

3. *Earthquakes in New England* (Appalachia, 1886, p. 190). —Professor W. M. DAVIS has in Appalachia an interesting map of the earthquakes of New England, illustrating an article on the subject.

4. *Medals of the Geological Society.* —The Wollaston Gold Medal, at the annual general meeting of the Geological Society of London in February, was given to the eminent mineralogist of France, Professor Des Cloizeaux; the Murchison Medal, to Mr. William Whitaker; the Lyell Medal, to Mr. William Pengelly, made famous by his investigations of the cavern, Kent's Hole; and the award from the Barlow-Jameson fund to Dr. H. J. Johnston-Lavis.

5. *Medal of the Astronomical Society of London.*—The gold medal of the Astronomical Society has been given to the Harvard astronomer, Professor E. C. Pickering.

The Auk. The Auk for April, 1886, contains a paper of sixty pages on the birds of the West Indies (including the Bahamas and the Greater and Lesser Antilles, excepting the islands of Tobago and Trinidad) by Charles B. Corey.

Plate IX.

THE

AMERICAN JOURNAL OF SCIENCE.

[THIRD SERIES.]

ART. XXXIX.—*The Biela Meteors of November 27th*, 1885; by H. A. NEWTON.

NUMEROUS notices of the brilliant meteor display of Nov. 27th (see p. 78) are given to us in the *Astr. Nachrichten*, the *Monthly Notices R. A. S.*, the *Observatory*, *Nature*, the *Comptes Rendus*, etc., by observers in various places over the Eastern hemisphere. The display in Western Europe occurred in the early evening hours, and it was reasonable to suppose that the shower would be visible over the Eastern Continent wherever the skies were clear. This seems to have been actually the case, though naturally the most valuable observations were made in Western Europe. There had been preparation for the shower by reason of anticipatory notices, especially one in a Dun Echt circular. Unfortunately in England, and at a few places on the continent, clouds seriously interfered with observing, though through breaks in the clouds much was seen notwithstanding.

Time of maximum.—The shower was in full activity in Europe at the close of twilight, and for a while increased in intensity. The time of the maximum was estimated.

At Pulkowa	at	8^h	15^m	P. m. t.,	that is,	6^h 14	Gr. m. t.
" Upsala		7	29·8	U. m. t.,	"	6 19	"
" Bonn (cloudy)		6	42	B. m. t.,			
" "		6	37	"	"	6 11	"
" "		6	40	"			

At Moncalieri the numbers given by P. Denza are:

6^h	0^m	to 6^h	15^m	Rome m. t.	2800	meteors	by 2	obs.
6	15	" 6	30	"	3100	"	2	"
6	30	" 6	45	"	3400	"	$2\frac{1}{3}$	"
6	45	" 7	0	"	4500	"	3	"
7	0	" 7	15	"	6200	"	4	"

The count was continued but clouds interfered. By a table quoted below we have for the ratio of the numbers of meteors visible to 2, 3 and 4 observers, 633 : 836 : 1000. P. Denza's observations reduced by these ratios show that the display increased in brilliancy until 7^h 15^m when the sky became partly overcast. The maximum indicated by them was then later than 7^h Roman, that is, 6^h 10^m Greenwich time. Professor Zona places the maximum earlier. Professor Cacciatori at Palermo gives 7^h 45^m (that is, 6^h 52^m) as the time of maximum. But clouds are reported during the preceding half hour. Many other observers give times of the maximum display which are more or less indefinite. We shall assume 6^h 15^m Gr. m. t. as representing very well the mean of all the observations.

Duration.—From the time of maximum the intensity quite steadily diminished. The numbers counted at Upsala show the course of the shower. The weather was fine and twelve observers under the direction of Messrs. Hildebrand-Hildebrandson and Charlier, looking toward different quarters of the sky kept count by quarter hours through five hours, with the following result (Greenwich time).

5^h	to	$5\frac{1}{4}^h$,	2545	$6\frac{3}{4}^h$	to	7^h,	3383	$8\frac{1}{2}^h$	to	$8\frac{3}{4}^h$,	799
$5\frac{1}{4}$	"	$5\frac{1}{2}$,	2287	7	"	$7\frac{1}{4}$,	2497	$8\frac{3}{4}$	"	9,	585
$5\frac{1}{2}$	"	$5\frac{3}{4}$,	2906	$7\frac{1}{4}$	"	$7\frac{1}{2}$,	2072	9	"	$9\frac{1}{4}$,	502
$5\frac{3}{4}$	"	6,	3382	$7\frac{1}{2}$	"	$7\frac{3}{4}$,	2295	$9\frac{1}{4}$	"	$9\frac{1}{2}$,	375
6	"	$6\frac{1}{4}$,	4213	$7\frac{3}{4}$	"	8,	1999	$9\frac{1}{2}$	"	$9\frac{3}{4}$,	307
$6\frac{1}{4}$	"	$6\frac{1}{2}$,	4422	8	"	$8\frac{1}{4}$,	1336	$9\frac{3}{4}$	"	10,	268
$6\frac{1}{2}$	"	$6\frac{3}{4}$,	3330	$8\frac{1}{4}$	"	$8\frac{1}{2}$,	1341				

The numbers diminished so that at the end of three hours from the time of the maximum there were only one-tenth of the maximum numbers of meteors. The end of the shower was not a definite epoch. Assuming that there was an increase during the sunlight and the twilight corresponding to the later decrease we may say in general terms that the shower lasted as an extraordinary display through six hours. Some of the reports from observers in Asia give reason to believe that the increase was less rapid than the decrease. A few Andromeda meteors were seen in different places on the night of the 26th, 28th and 29th, but the number of them on each night was not large.

Hourly number of meteors at the time of maximum.—As has been noticed in other showers the meteors were not evenly distributed in time but came somewhat fitfully. There is moreover great discrepancy in the numbers counted by different observers. The numbers of persons counting, the precautions to prevent duplication, the relative directions in which they looked, and the state of the sky are in many cases not given, and this renders the comparison of numbers reported from different places difficult.

An experiment made in 1865 by the writer gave the following ratios (y) for the numbers of shooting stars seen by from one to twelve observers (x). The group of observers is presumed in each case to have the points toward which they are looking symmetrically distributed over the heavens.*

x	y	x	y	x	y
1	325	5	1106	9	1399
2	633	6	1200	10	1451
3	836	7	1282	11	1509
4	1000	8	1348	12	1560

These values of y should increase toward a limit when x increases indefinitely. The limit is evidently more than 2000, and as the differences near the end of the table decrease very slowly, I do not regard 2400 an extravagant estimate. I shall therefore use that factor in some subsequent computations.

Of the shower of Nov. 27th no published set of observations show more completely the course and intensity of the shower than those above cited made at Upsala. They imply at the maximum an hourly number of $4\times4422\times2400\div1560$ (that is about 27000) for the total number visible at Upsala. They also give for the quarter-hour number for one observer at their maximum $4422\times325\div1560$ (that is, about 60 per minute.)

At Marseilles three observers (Stephan, Borrelly and Coggia) in several trials counted over 600 per minute, which represents 233 per minute, for one observer and a *total* hourly number of over 100,000. At moonrise ($10\frac{1}{2}^{h}$) there were 50 to 60 a minute counted.

At Palermo the maximum number per minute reported was 214 for two observers from $7^{h}\ 43^{m}$ to $7^{h}\ 48^{m}$.

At Geneva 55 to 60 a minute were reported. The sky was partly clouded.

* Dr. Kleiber (*Astr. Nachr.*, No. 2621) has given a similar table from some observations made by him in 1884 at St. Petersburg. As he has in his discussion, however, taken every possible combination of his eight observers instead of considering such combinations as contain observers looking to different parts of the heavens, Dr. Kleiber's numbers and mine represent different quantities, and are not properly comparable. His method of reduction seems to me faulty, and to have vitiated his results for practical use.

At Glasgow one observer counted 74 in a minute at 6^h 10^m, and another counted 100 in a minute at 6^h 24^m.

At Greenwich there were 30 to 40 a minute for one observer between 6^h and 7^h.

From Beyrout, Professor Robert H. West of the Syrian Protestant College reports in *Nature* (vol. xxxiii, p. 152): "The maximum appears to have been between 8 and 9 o'clock. At 6^h 3^m two observers watching opposite parts of the sky counted 850 meteors in five minutes. At 7^h 50^m (5^h 30^m Greenwich mean time) seven observers divided the heavens among them and together counted 525 in one minute. We all agreed that we had not been able to count all that we saw, so that this number is probably too small. At any rate I do not think the number of meteors visible between 7 and 9 P. M. was at any time less than 500 per minute. At 10^h I alone counted 210 in two minutes, facing the north, which was then partially clouded."

The number 525 for seven observers corresponds to $525 \times 325 \div 1282 = 133$ per minute for one observer, and to a total hourly number (computed as before) of 59,000. The count of 850 in 5^m for two observers represents 87 per minute for one observer.

At Moncalieri the 6200 for 4 observers in a quarter hour in like manner represents about 60,000 per hour for the total number visible.

In many other places larger or smaller numbers were reported. Over 100 in individual minutes were counted by a single observer in several places. It can hardly be doubted that there was a purer sky and so a larger number of meteors visible at Beyrout, Moncalieri and Marseilles than at Upsala and Greenwich.* In computing the hourly number of meteors visible we should choose the clearer rather than the hazy skies. Probably it will not be considered unreasonable to assume from these observations, that the density of the meteor stream in its central and densest portions may be fairly expressed by 75,000 meteors per hour visible at one place in a very pure clear sky by a very great number of observers.

By an extended examination of meteor paths it was shown in 1864 (this Journal, II, xxxix, p. 196) that *about one in fifty* (one in 50·35) of *all shooting stars visible at a place should have the middle points of their apparent paths within* 10° *of the zenith.* The hourly number of meteors within 10° of the zenith at the time of the maximum, Nov. 27th, was then 75,000/50, or 1500.

* It is not reasonable to suppose that the product of the number of meteoroids that entered the air near the several places multiplied by the cosine of the zenith distant of the radiant greatly differed. Can a different constitution of the upper strata of the atmosphere, by reason of which paths become more brilliant in one place than in another be admitted as possible?

Following a similar process of reasoning to that of the article referred to, we may compare the number N of meteor tracks which are visible during a given time at one place whose middle points are within 10° of the zenith, with the number N′ of tracks visible during the same time (not necessarily visible all at one place) whose middle points are in a right cylinder of circular base whose radius is r, and whose axis proceeds from the observer in the direction of the radiant. The following proportion is readily formed:

$$\mathrm{N}:\mathrm{N}'::\int_a^b \pi\rho x^2 \tan^2 10°\, dx : \int_a^b \pi\rho r^2 \sec z\, dx :: \tan^2 10° \int_a^b \rho x^2\, dx : r^2 \sec z \int_a^b \rho\, dx,$$

in which x expresses the height from the ground of middle points of meteor tracks, a and b the limiting values of x, z the zenith distance of the radiant, and ρ a factor proportional to the mean density of the meteor tracks at different altitudes, which is assumed to be a function of x only.

If we further assume that the values of ρ in the present shower are equal to those used in the memoir cited, and which were obtained from all the measured altitudes of shooting stars then available, we shall have for ρ at elevations of 45, 75, 105, 135 and 165 kilometers the several values 114, 243, 277, 106 and 57.

Using finite summation for integration we have,

$$\Sigma\rho\Delta x = 797\,\Delta x, \text{ and } \tan^2 10° \,\Sigma x^2 \rho\Delta x = 252930\,\Delta x;$$

hence the above proportion gives $\mathrm{N}' = \cdot 00315\, \mathrm{N} r^2 \sec z$ where r is to be expressed in kilometers.

The radiant at the time of the maximum of the shower was vertical over the Caucasus, and the value of sec z for the several stations varied from 1·02 to 1·15. I shall use the value 1·08 for sec z, and 1500 for N for an hour. This gives $\mathrm{N}' = 5\cdot 1 r^2$ for one hour, in other words, at the maximum of the shower there were 5·1 meteors per hour, the middle points of whose visible paths were in a fixed right cylinder whose axis was parallel to the relative motion of the meteoroids, and whose radius was one kilometer. But such a cylinder evidently received all the meteoroids of a cylinder of nearly equal radius located in the meteoroid group, and whose length was the hourly motion of the meteoroids relative to the earth before the earth began sensibly to attract them.

The velocity of the Biela meteoroids relative to the earth (using the orbit of 1852), is found by Weiss to be ·53484. (Beiträge zur Kenntniss der Sternschnuppen I, p. 11.) The earth's velocity being 29·8 kilometers per second, we get

57,300 k. for the meteoroid's relative velocity per hour. *The space in the meteoroid group corresponding to each single visible meteor was therefore, in the densest portion of the group, a cube whose edge in kilometers is the cube root of* $57{,}300\pi/5{\cdot}1$, *that is,* 32·8 *kilometers*, or 20·4 miles.

Thickness of the stream of meteors.—As the earth has a velocity of 18·5 miles a second and its orbit has an inclination to the stream of 12° 33′, the earth's motion perpendicularly to the stream is 14,500 miles per hour, or 87,000 miles in six hours. The really dense portion of the stream was then less than 100,000 in breadth and nearly all of it was included in a belt 200,000 miles in thickness. One hundred thousand miles subtends at the sun an angle of 3′·7.

Radiant of the meteors.—Nearly every observer paid special attention to the radiant, so that perhaps at no previous time has there been so generally an effort to determine its position accurately as in the present shower. The result is correspondingly instructive. I have collected in the following table a considerable number of places assigned for the radiant, applying in a few cases a correction for precession to reduce from the date of the chart to the equinox of 1885·0. With some of these there is given the hour of the evening to which the radiant belongs, but the larger part are without such an indication. Five of them reported by Mr. Denning, at Bristol, are for preceding and following evenings. About seven-eighths of these tabular places are represented in the accompanying figure, p. 417, the remaining places being beyond its limit. The Pulkowa observations are plotted with R. A. 25°·5.

Place.	Observer.	R. A.	Dec.
Agra,	Strahan,	26°·2	46°
Mauritius,		near	γ Andr.
Beyrout,	West,	25·5	43·5
Athens,	Lephay,	21	32
Pulkowa,	Romberg,	24–27	44
"	Backlund, etc.,	24–27	46
"	H. Struve,	24–27	48
"	O. Struve, etc.,	24–27	50
"	L. Struve, etc.,	22	53
"	"	24	44
Upsala,	Gyllenskiöld,	23·7	44·4
"	"	22·3	44·2
"	"	21·0	44·2
"	"	25·6	45·9
"	Fineman,	22·6	41·5
"	"	22·15	44·9
"	"	21·65	45·4
"	Charlier,	23·4	45·0
"	"	24·6	45·5

Place.	Observer.	R. A.	Dec.
Upsala,	Charlier,	23·9	47·3
"	Schultz—Steinheil,	25·2	42·5
"	Meyer,	22·05	46·4
Helsingfors,	Donner,	22·5	53
Vienna,	Weiss,	near	γ Andr.
Prague,	Weinek, etc.,	"	"
"	Safarik,	21·5	42
Breslau,	Galle,	27·1	43·9
"		27·7	43·5
Tuschkau,	Kaschka,	30·8	49·4
Königsberg,	Rahts,	23·1	43·8
"	Franz,	24·4	44·3
Berlin,	Förster,	25·7	43·2
"	v. Sichart,	25	45
Bremen,	Meinardus,	17	45
Leipzig,	Bruns,	22·6	48
Munich,	Oertel,	near	γ Andr.
Patenkirchen,	Ward,	"	χ "
Bonn,	Schönfeld,	24·7	44·2
"	Deichmüller,	16·4	44·9
Cologne,	Klein,	near	γ Andr.
Arnsberg,	Busch,	22	39
Essen,	v. Heyden,	30	50
Osterath,	Meller,	24	42
Malta,	Scoles,	21	46
"	v. Tucher,	27·7	42·5
Palermo,	Zona,	22·4	42·6
"	"	22·9	41·9
"	"	24·4	40·9
"	"	23·4	41·8
"	Ricco,	25·4	41·1
Milan,	Schiaparelli,	15	45
"	"	18·5	44
"	"	23	42
Moncalieri,	Denza,	22	44
"	"	26	43
"	"	28	42
Geneva,	Kammermann,	24	41
Deventer,	Sirks,	23	42
Sneek,	Nÿland,	21	42
Enscheele,	v. Deinse,	22	43
Dongen,	v. Boxel,	25	39
Ougrée,	DeBall,	22	42
Nice,	Perrotin,	24·2	43·1
Marseilles,	Stephan, etc.,	22·5	49·2
Grignon,	Jehl,	23	42
Bordeaux,	Rayet,	28·5	46
Alton,	Howlett,	near	γ Andr.
Chepstow,	Lowe,	"	"
Bristol,	Denning (26)	26	44

Place.	Observer.	R. A.	Dec.
Bristol,	Denning (26)	27	43
"	" "	26	43·5
"	" (27)	24	43·5
"	" "	23	45
"	" (28)	22	43·5
"	" (30)	21	42·5
Harrow,	Tupman,	27	44
"	"	22·5	45·5
Greenwich,	Nash,	20	49
Stonyhurst,	Perry,	24	41
Oxford.	Stone,	22·5	42
"	Wickham,	10·3	52
"	Plummer,	21	45
"	Jenkins,	23	46
Dun Echt,	Copeland,	25·9	46·4
Dundee,	Smieton,	21	44
Glasgow,	Grant,	24	45·5
Cape Town,	Gill,	39	27
New Haven,	Newton,	near	γ Andr.
Cambridgeport,	Sawyer,	22·5	42·5
Princeton,	Young,	27·5	43·5

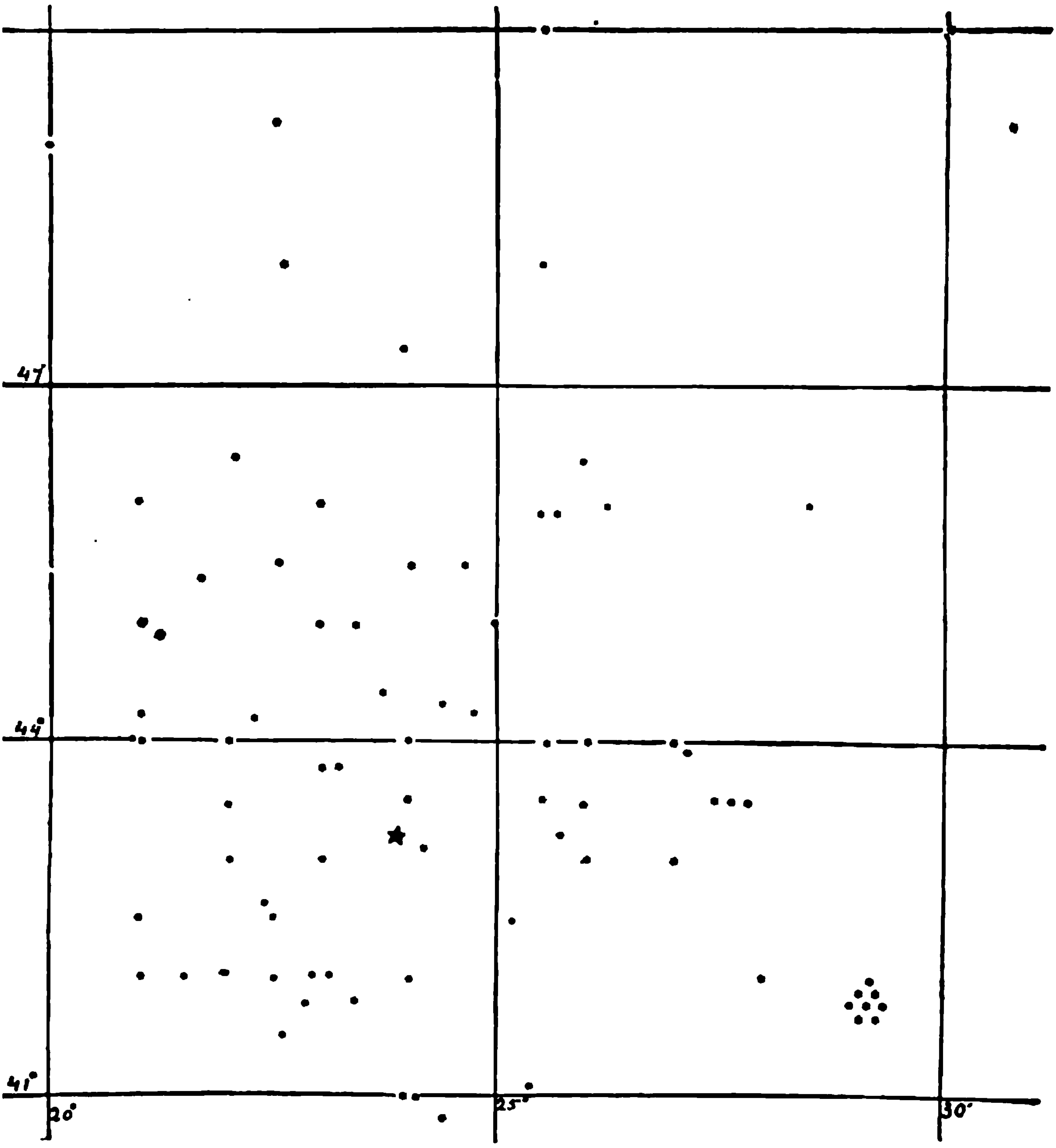
The object of forming this table is not to obtain the best possible observed place of the radiant. If this had been intended, there are many indications that some observations are entitled to considerable confidence and that some are not much to be relied on. The object is rather to bring out distinctly the fact that the radiant was not a mathematical point nor even a very small area. A considerable number of the observers distinctly stated that the tracks did not radiate from a point. Some thought there were two or more centers of dispersion. The same want of strict radiation from a center has been noticed in nearly every star-shower since 1833, the time when radiation was first noticed, and is shown equally when the tracks near the radiant are charted, and when the observer watches the stars near the radiant for the very purpose of deciding this question. Of course tracks beginning at a great distance from the radiant are of little use in determining the size and shape of the radiant area.

There are two corrections that should in strictness be applied to all these assigned positions, one for the zenithal attraction, and one for the observer's motion with the earth's rotation. The Biela meteors have a slow initial velocity relative to the earth, equal to 9·9 miles a second, and the same is increased before the earth's surface is reached to about 12 miles a second. Not a little deviation from the original direction is by reason of this slow velocity caused by the earth's attraction. The deviation is in the vertical plane, and is a function of the zenith distance very much like refraction.

The observed radiant is nearer the zenith than the original direction with which meteors approach the earth.

An approximate correction for this cause can be easily computed. For this we may disregard the height of the air, and assume that the meteors come to the ground. Also, the meteors may be regarded as coming in a hyperbolic orbit from an infinite distance instead of being only for a finite distance within the dominant influence of the earth's attraction.

Chart showing the places assigned to the radiant. The cluster is at γ Andromedæ. The large star is the place of the radiant corresponding to the Biela orbit of 1852.



Let us consider a single meteor that comes to the earth's surface, at the observer's place. The tangent to its path would then be directed to the observed radiant of a group that moved parallel to this single meteor. Let z be the angle which this path makes with the vertical line of the observer and x be the

quantity sought, namely, the angle through which the direction of path has been changed. The asymptote of the hyperbola makes then an angle $z+x$ with the vertical. Let the velocities at infinity, at the earth's surface, and what should be attained, at the perigee of the hyperbolic orbit, be respectively v, v_1 and v_0; let p, p_1 and p_0 be the perpendiculars upon the corresponding tangents; let g, a, b, and e, be the force of gravity, the semi-axes and the eccentricity of the hyperbola; let θ be the angle at the earth's center between the lines to the observer and to the center of the hyperbola, α the angle between the original direction of the meteor and the conjugate axis of the the hyperbola, and r the earth's radius.

Then we have,

by conservation of areas, $vp=v_1p_1=v_0p_0$; (1)

by conservation of energy, $v_1^2-v^2=2gr$, and $p_0(v_0^2-v^2)=2gr^2$; (2)

by nature of the hyperbola,
$$\left\{\begin{array}{ll} a=b\tan\alpha,\ p=b,\ e=\operatorname{cosec}\alpha, & \\ r(1+e\cos\theta)=a(e^2-1), & (3)\\ p=p_0(\tan\alpha+\sec\alpha), & (4)\end{array}\right.$$

Also $p_1=r\sin z$.

From (4) $$\frac{p}{p_0}-\frac{p_0}{p}=2\tan\alpha,$$

and from (1) and (2) $$\frac{p}{p_0}-\frac{p_0}{p}=\frac{2gr^2}{pv^2},$$

hence $$\frac{gr^2}{v^2}=p\tan\alpha=b\tan\alpha=a. \qquad (5)$$

Again from (1) and (2) $$\frac{v_1}{v}=\left(1+\frac{2gr}{v^2}\right)^{\frac{1}{2}}=\frac{p}{p_1},$$

hence $$b=p=r\sin z\left(1+\frac{2gr}{v^2}\right)^{\frac{1}{2}}=\sin z(r^2+2ar)^{\frac{1}{2}} \qquad (6)$$

and from (3) $$\cos\theta=\frac{a}{r}\frac{(e^2-1)}{e}-\frac{1}{e}=\frac{a}{r}\cos\alpha-\sin\alpha. \qquad (7)$$

But evidently $$\theta+z+x=\frac{\pi}{2}+\alpha, \qquad (8)$$

since each member is equal to the angle between the transverse axis of the hyperbola and the asymptote. The equations (5), (6), (7) and (8) enable us to compute a, b, α, θ, and x for given values of z. Taking $g=32{\cdot}12$ feet, $r=3956$ miles, $v=9{\cdot}9$ miles, we obtain this table of values of x with argument z.

z	x	z	x	z	x
10°	1° 0′	40°	4° 9′	70°	8° 0′
20	2 1	50	5 19	80	9 35
30	3 3	60	6 36	90	11 22

Hence we may say that *the earth's attraction changes the radiant of the Biela meteors toward the vertical of the observer.*

one-tenth of the observed zenith distance of the radiant. When the radiant is near the horizon the change is somewhat greater than one-tenth of the zenith distance.

The radiant was to the east of the greater number of observers until the shower had nearly ceased, and the correction would be generally under 2°, though in some cases exceeding that amount.

A second correction to the observed place of the radiant is required by reason of the motion of the observer due to the rotation of the earth on its axis. This correction must be applied before the observed places can be compared with each other, or with a radiant deduced from the orbit of a comet. For the Biela meteors this may be easily shown to be about 1°·0×sine of the arc from the east point of the heavens to the radiant and is to be applied to increase that arc. It is nearly constant for the European observations in the table.

These two corrections do not appear, however, to bring the scattered radiant positions any nearer together. We cannot, therefore, regard the earth's attraction and rotation as having much to do with their wide distribution over the constellation from which the meteors proceed.*

The luminous portions of meteor tracks are usually to the eye arcs of great circles. It is only in rare cases that the path appears curved. The luminous paths of the meteors were therefore straight lines, but were not parallel lines, for had they been parallel, the radiant should be a mere point, and not an area. How much they deviated from parallelism it is not easy to determine with exactness. That their directions differed from the average direction of the group by angles which for a considerable fraction of the whole number of meteors amounted to several degrees, seems a proper and necessary inference from the wide scattering of the radiant points as described by the observers and represented in the figure on page 417. Mr. Denning says (Mon. Not. R. A. S., xlvi, p. 69), "The area of radiation must have been fully 7° in diameter to accommodate the discordances in the flights. The center was at 24°, +44°, but I saw several very short paths from a point south of γ Andromedæ. I noted many of the meteors with the utmost care in order to assure myself of the diffuseness of radiation, and it was found impossible to get a sharply defined position.

* Since writing the above, Professor Fœrster's paper, in No. 2720 of the Astr. Nachr. containing a discussion of thirty-two assigned positions of the radiant in this shower has been received. He applied the above two corrections to the observed places, and gives the reduced R. A. and declination of each assigned radiant. If the means of the observed R. A.'s or declinations be taken, and their deviations from the observed added together (neglecting sign), the sum is 97°·7. But if the corresponding sum of differences be taken for his reduced places, the sum is 98°·8. In other words, the radiants are equally scattered before and after correction.

The contrary effect was indeed so obvious as to arrest the eye whenever simultaneous bursts of about six or seven meteors took place near the radiant. It was then seen that the collective flights were not symmetrical emanations from a central point. They rather appeared to be discharged in a loose, disjointed fashion from a comparatively large space on the N.W. region of γ Andromedæ, and just perhaps enveloping that star within its limits." Similar testimony is given by other observers.

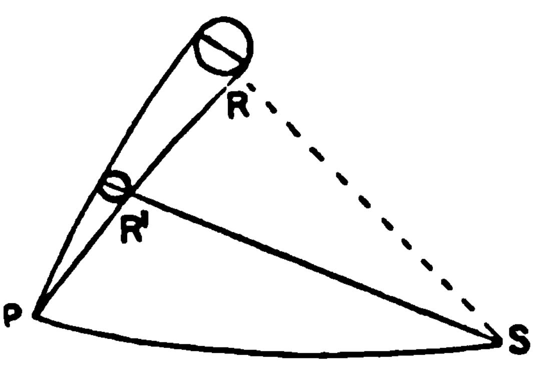
We must then accept one of two propositions: either the luminous paths are not true continuations, unchanged in direction, of the orbital paths of the meteoroids as they approach the earth; or else these orbital paths make angles of several degrees with their mean direction. The first alternative seems the more probable.

The meteoroid is probably a fragmentary body of irregular form. The meteorites which come to the ground are fragments, and nothing in their structure suggests a spherical or otherwise regular form upon entering the air. A small irregular body could not traverse with great velocity a fluid, even a fluid of extreme rarity, without there being developed such unsymmetrical resistance as would cause a curvature of path or glancing of the stone. This unsymmetrical resistance would continue so long as the stone retained its original irregularity. But in time the condensed air in front of the stone becomes hot enough to melt or burn off the stone. The thin angles in front must of course burn first. The melted matter being wiped off by the atmosphere, the anterior surface is rounded in such manner that the resistance of the air upon the stone becomes symmetrical. Thenceforth the path, now a luminous trail, is in general a right line. Curvature of path is an exceptional instead of an ordinary occurrence.

This rounding of one or more sides of the body is very clearly shown in many meteorites. Thus the Emmet Co. meteor broke into a very great number of large and small irregular fragments, and the small fragments retained enough velocity to burn after leaving the parent mass. Rounded surfaces evidently produced by the melting and wiping off of the material by the air are characteristic of these smaller pieces, several thousands of which have been collected.

The alternative proposition is that each luminous path is a portion continuous in direction, of the meteoroid's orbit about the sun and earth. Upon this hypothesis the orbits of different members of the group are not parallel, but the motions relative to the earth differ in direction by angles which amount in some cases to many degrees. The mean of the deviations from a common direction would be measured by degrees and not by minutes.

Suppose the directions of the luminous paths regarded as right lines to be first corrected for the earth's attraction and rotation as heretofore indicated, and the corrected lines to be produced indefinitely. They will intersect the celestial sphere in and near the constellation Andromeda. The most of the points will lie in an area comparable in size with the area dotted over by the assigned radiants, as shown in the figure on p. 417. Probably the points would be somewhat more widely distributed than the assigned radiants, since these latter are *centers* of radiation deduced each from many observed paths. Let an area R be taken on the celestial sphere that shall contain the principal part of the points so determined, an area that for convenience may be taken of an oval form. To this area R corresponds a second area R′, such that R′ bears the same relation to the motion of the meteoroids relative to the sun as R does to the undisturbed motions relative to the earth. The area R′ may be thus constructed. Let P be the point of the celestial sphere from which the earth is moving. To any point in R will correspond a point in R′ co-planar with P and conversely. Hence great circles from P touching R will be tangent to R′. If u be the earth's velocity, and v the meteoroids' velocity relative to the sun (which may be assumed to be the same for all the meteoroids), then by the law of composition of velocities, $v : u :: \sin$ PR : sin RR′. The dimensions of R′ for the Biela meteors will be easily found to be in one direction about $\frac{4}{9}$, and in the other about $\frac{2}{3}$ of the dimensions of R. Therefore for the shower of Nov. 27th, R′ is measured by degrees rather than minutes.



If the orbits of the Biela meteoroids were nearly (or quite) co-planar the area R′ would be a narrow oval (or a mere line). And if S be the earth's place as seen from the sun at the time of the shower the major axis of the oval (or the line) would be co-planar with S.

But to each point in R′ corresponds a point in R, and if R′ is a narrow oval (or line), R will also be a narrow oval (or line, which would be in fact, a portion of a sphero-conic). The lengths of lines in R will be to the lengths of corresponding lines in R′ in ratios not much greater than 9 : 4, nor much less than 3 : 2.

Now the thickness of the dense part of the stream subtends at the sun as was seen, an angle of about 3′·7. Therefore, either there is something like a nodal point of the meteoroid orbits near where the earth's orbit cuts them, or else the deviation of the planes of the orbits from their mean plane is generally not greater than one-half of 3′·7. Because a large group of orbits whose planes intersect the mean plane at angles

near 90° distant from where the shower happened would give a stream of meteors nearly equal in thickness to the radius of the earth's orbit into twice the limiting angle of the inclinations of the individual orbits to the mean orbit.

Unless therefore there is a nodal region for the several orbits near the ecliptic the area R′ must have a breadth not much greater than 3′·7, and consequently R a breadth not much greater than 6′ or 8′ in a northerly and southerly direction.

Again if the meteoroid orbits are nearly co-planar, and we compare two orbits corresponding to two points at the extremities of the narrow area R′, it is easily seen that the tangents to these two orbits make an angle with each other equal to the length of R′. Now if two equal elliptic orbits of great eccentricity and a common focus cut each other at a small angle near perihelion the lines of apsides of the two orbits make an angle with each other, nearly twice that made by the orbits themselves at their intersection. Hence the major axes of the two orbits corresponding to the two extremities of R′ make an angle with each other nearly double the length of R′, that is, nearly the length of R. That is, if R is several degrees long E. and W., the lines of apsides of the meteoroid orbits are distributed over several degrees. The group itself therefore must have enormous extent nearly in the mean plane, especially at aphelion. This would be true even if we suppose that the orbits have a nodal point at the place where they cut the ecliptic. Such scattering seems inconsistent with present compactness of the group, and a common history.

That there should be nodal points, either of inclination of planes or of intersection of orbits, where the earth cuts the meteoroid stream might be supposed possible if we had but one meteor-swarm to consider. But the same hypotheses must be for like reasons extended to the Leonids, and Lyraids, and perhaps to the Perseids. Unless the earth has been the controlling body in the history of all these swarms such hypotheses are violently improbable.

The more reasonable explanation therefore of the large area of radiation of the meteors of the Biela and other star-showers is the glancing of meteors on entering the air. The burning off of the angles of the solid fragments as soon as burning begins makes them move in straight lines thereafter. The curvature of path otherwise should continue through the whole length of the luminous tracks.

This glancing is not confined to the Biela meteors. It was true of the Leonids and still more of the Perseids. It is reasonable to assume that it is true of all shooting stars. It is not therefore as simple a matter as some have supposed to separate meteors into groups, alloting them to different radiant points, or to establish the persistency or change of such points.

To the uncertainty of the observation of a path, which with the very best observers amounts to two or three degrees, is to be combined this uncertainty of the amount and direction of its early glancing, which amounts also to several degrees. Besides all this there is the uncertainty due to the fact that any point above the horizon in a meteor path produced backward may have been its radiant. Any radiant that has been determined from a small number of paths must be very unreliable, and if the observations of the paths themselves have not been published the value of such determination as a contribution to astronomy is still farther diminished.

Movement of the nodes of the comet's orbit, and corresponding change of date of the shower.—The longitudes of the nodes of the orbit of the comet were greatly changed between its discovery in 1772 and its last appearance in 1852. The earth at first passed the node in the second week in December, but a change of ten or twelve days had brought it down to Nov. 27th before 1852.

The following table contains the longitudes of the nodes of the orbit reduced to the equinox of 1885·0, together with the inclination of the orbit to the ecliptic, for the successive appearances of the comet. The corresponding quantities for 1859 and 1866 are added from the orbits computed by Michez, the computation having taken account of the changes of these quantities in the interval from 1852. Since 1866 the perturbations of these quantities have been small, since Jupiter has not been at any time very near to the comet.

Longitudes of the nodes and inclinations of the orbit of Biela's comet at its successive appearances.

Year.	☊	i	Year.	☊	i	Year.	☊	i
	°	°		°	°		°	°
1772	258·7	17·1	1833	249·0	13·2	1859	246·1	12·4
1806	252·4	13·6	1846	246·5	12·6	1866	246·0	12·4
1826	251·2	13·6	1852	246·3	12·6			

With the progression of the node corresponds a progression of the star-shower, and with the change of inclination corresponds a change of radiant to the south. In 1798, on the evening of December 6th, Brandes counted for about four hours as many as 400 shooting stars. They diminished rapidly after 10 o'clock. In 1838 Mr. Herrick, on the evening of December 7th, with an assistant, counted 93 meteors in an hour radiating "from a spot not far from Cassiopeia; or perhaps, more nearly, from the vicinity of the cluster in the sword of Perseus. The radiant, however, could not well be fixed within three or four degrees." Observations at New Haven and elsewhere show that the maximum was on that evening. In 1847 Professor Heis at Aix la Chapelle observed on the evenings of December 8th

and 10th and recorded 226 meteors, a portion of which he has classified as radiating from R. A. 22°, Dec. +55°. If from the meteors recorded by him on those two nights we select all those whose paths produced backward would pass near Cassiopeia or Andromeda, and at the same time make a considerable angle with the meridian, we have about 27 which cross the 20° hour circle north of 50° declination, and 9 south of 50° declination. The large north declination of 55° assigned by Heis for the radiant is, therefore, required by the paths as recorded. There is no indication of the time of maximum. In 1867, Zezioli on the evening of November 30th, saw seven meteors, which Schiaparelli assigns to the radiant, R. A. 17°, Dec. +48.

The great shower of 1872 had its maximum at Nov. 27·34, Gr. m. t. The mean of 90 assigned radiants considered as single points was given by Professor A. S. Herschel as R. A. 24°·54 Dec. +44°·74 (Monthly Notices R. A. S., xxxiii, p. 504).

The longitude of the earth at the times of these several dates is given in the following table (equinox 1885·0):

Table of sun's longitudes at the dates of meteor displays.

Year.	Long. ⊙	Year.	Long. ⊙	Year.	Long. ⊙
1798	256°·2	1847	257°·7	1872	246°·1
1838	256·1	1867	248·4	1885	245·8

Since the Biela meteoroids are encountered at the *descending* node of the comet's orbit, the longitude of the ascending node and the longitude of the sun are quantities to be compared. It will be seen at once that on the first three of the six dates, viz: 1798, 1838, and 1847, the sun's longitude was about that of the node of the comet's orbit in 1772, differing from it by an amount easily explained by the action of Jupiter at some distance. On the contrary, the few meteors seen by Zezioli and the two grand meteor showers of 1872 and 1885 are related to the orbit of the comet since its near approach to Jupiter in 1841–42.

The change of declination of the radiant shows the same fact. Professor Weiss gives the radiants for the Biela orbits as follows (eq. 1850) [Beitrage, etc., p. 15]:

Year 1772	R. A. 18°·7	Dec. +58°·1
" 1826	" 22·8	" +47·7
" 1852	" 23·4	" +43·0

The meteors of the years 1838 and 1847 have a radiant corresponding very well with that of the 1772 orbit, while the radiants of 1867, 1872 and 1885 are well represented by that belonging to the orbit of 1852.

The comet approached Jupiter and was greatly perturbed in 1794, 1831, and 1841–42. It is very difficult to conceive of

any way in which the meteors of 1872 and 1885 could be sent around in such a thin stream as we encountered, and one so near to the plane of the comet's orbit, unless they were a very compact group, and were also very near to the comet, as late as its near approach to Jupiter in 1841–42. If they left the comet before that time the effect of Jupiter would not be the same on the meteoroids as on the comet, and if they at that time formed an extended group, such disturbance as the comet suffered would have scattered the group, and we should have had a much less brilliant star-shower in 1872 and 1885.

Assuming, then, that the comet and the meteoroids were very near each other, if not united, at the date 1841·5 it seems possible to compute the disturbing forces and the resulting orbit along which some of these bodies traveled from that date until they met the earth in 1872, and also the orbit along which others traveled to meet the earth, Nov. 27, 1885. The observed orbits of the double comets in 1845–46 and in 1852 furnish the basis of such a computation. Possibly the result will give evidence for or against a resisting medium in the solar system.

We are moreover entitled to conclude that the process of disintegration of the comet is quite rapid. The non-appearance of the comet in recent years has like significance.

The following is a summary statement of conclusions:

1. The maximum of the shower was near 6^h 15^m Gr. m. t.

2. Three hours after the maximum the numbers of meteors had diminished to one-tenth the maximum number, and it is not unreasonable to assume six hours as containing the principal part of the shower.

3. The total hourly number of meteors visible at one place in a very clear sky, to some one or other of a very large group of observers may at maximum be regarded as 75,000.

4. In the densest part of the meteor stream where and when the earth encountered it, the space that corresponded to each meteoroid was equal to a cube whose edge was about 20 English miles.

5. The dense part of the stream was not over 100,000 miles in thickness.

6. The *zenithal attraction* of the Biela meteors was about one-tenth of the observed zenith distance of the radiant.

7. The radiant was an area several degrees across.

8. It is reasonable to suppose that the meteoroids while in the upper part of the atmosphere, before the paths become luminous, change direction by a glancing, due to irregularity of form. After the resistance has developed heat enough to melt or burn off projecting angles of the stones, and the tracks

become luminous, the forms of the bodies become rounded in front, and the paths described are straight lines.

9. The meteoroids encountered by the earth on the 27th of November, in 1872, and in 1885, did not leave the immediate neighborhood of the Biela comet earlier than 1841·5, and may be treated as having at that time orbits osculating that of the comet. The determination of the paths of these meteoroids through their five and seven last revolutions about the sun seems to be a problem capable of complete solution.

ART. XL.—*The Ultra-violet Spectrum of Cadmium;* by LOUIS BELL, Fellow in Physics of the Johns Hopkins University.

As the ultra-violet spectrum of cadmium has long served as a standard of reference in the measuring of other spectra it has seemed desirable to determine its principal wave-lengths with an accuracy greater than has been heretofore reached. Thus far all determinations of ultra-violet wave-lengths have depended, in general, upon the method devised by Cornu, that of photographing upon the same plate the lines in question and a series of direct reflections of the slit corresponding to known angles of deviation.

While this process is an ingenious one and has done good service in preliminary work, it is clear that the accuracy of which it is susceptible is decidedly limited. For in the first place it is liable to the errors that always attend the determination of an angle by a small number of measurements and in addition to the numberless minor difficulties that must attend the taking and measuring of small photographs when the dispersion used is not large and the focussing is mainly a matter of experiment. A casual examination of the wave-lengths given for the same lines by various experimenters will give a clear idea of the difficulties and faults of the method. Even the numbers given by such careful workers as Cornu and Hartley not infrequently differ by as much as one part in five thousand.

A radically different method has been used in making the determinations reported in the present paper. The apparatus used has been the great spectrometer in the physical laboratory of this university, armed with a concave grating of twenty-one feet focal length and containing, in the space of six inches, nearly 80,000 lines. An idea of the dispersion produced by this instrument may be formed from the fact that photographs taken directly in the focus of the third order are on a scale somewhat larger than that of Ångström's map. An eyepiece micrometer with a very accurate screw two decimeters in length answers for the exactness of all measurements made in the vis-

ible spectrum. As the overlapping spectra of different orders are focussed in precisely the same plane, and the great focal length of the grating ensures a perfect focus in photographs over a foot in length, the method of coincidences can be used with the greatest exactness throughout the ultra-violet.

In using this apparatus the method employed was in detail as follows:

The first step was to determine with the greatest possible accuracy, the wave-lengths of the principal visible lines in the spectrum of cadmium. As the source of light, poles were made from cadmium which had been subjected to fractional distillation in vacuo, and the spark taken between them from a good sized induction coil furnished with a quart Leyden jar and worked by twelve Bunsen cells. The poles were separated somewhat over a millimeter and placed as close as possible to the slit. The slit also received the image of the sun from a heliostat and quartz lens and was closed until either the solar or the cadmium spectrum could be seen with equal sharpness of definition. Then the cadmium line to be measured was put near the center of field of the eyepiece micrometer and micrometer readings were taken on solar lines of which the wave-lengths were very accurately determined. When the place of the cadmium line was reached the sunlight was cut off for a moment and a reading was taken on the cadmium. Then the light was readmitted and the measurements on the solar lines continued.

This process was repeated several times and since the utmost care was taken that the light from the poles and from the sun should fall upon the grating in exactly the same manner, the micrometer readings gave the wave-length of the cadmium line with a very high degree of accuracy. The error of a wave-length thus determined can in no case be as great as one part in a hundred thousand, and usually it is much less. Independent measurements made on different days do not differ by more than this amount.

The solar lines on which the exactness of the work depends are determined to one part in half a million so far as relative wave-length is concerned. The cadmium lines thus measured were seven in number, and had wave-lengths, 6438·77, 5338·50, 5379·22, 5086·09, 4800·15, 4678·39, 4414·19, being Mascart's first seven lines.

Next in order came the determination of the extreme ultra-violet rays. Cadmium fortunately has a very prominent group of lines near wave-length 2300. Therefore a photograph of the last three lines mentioned above, taken in the first order, would include this ultra-violet group in the second order. And since both orders were in focus together, the wave-lengths could be

very exactly determined by a simple linear measurement. Several photographs of this region were taken, and measured very carefully by means of a dividing engine provided with an accurate screw and reading microscope. To make sure of accuracy the slit was narrowed until only the strongest lines appeared, while the definition was exceedingly sharp. Five strong lines were thus measured, taking mean of measurements from four negatives, with the following resulting wave-lengths, 2321·14, 2312·83, 2288·01, 2264·88, 2264·42. It is highly improbable that these are in error by as much as one part in fifty thousand. The last two lines of this group form a sharp double which with the dispersion and resolving power usually employed appears as a single strong, broad line with a conspicuous nimbus, Mascart's twenty-fourth line.

Having thus determined both ends of the spectrum with a satisfactory degree of exactness, the next step was to connect them by a series of negatives overlapping each other considerably and sharp enough to yield accurate measurements for the positions of the principal lines. As the only object in view was the determination of a series of standard wave-lengths, no attempt was made to photograph the fainter lines, but the slit was narrowed to secure the best definition practicable.

The main difficulty to be met in photographing spark spectra with the concave grating is lack of light. In spite of the large size of the grating its great focal length reduces the light so much that with the spark apparatus available it was best to photograph mainly in the first spectrum, although several negatives were taken in the second as a check upon the work. A string of seven negatives was then taken, overlapping by a considerable amount, and covering in all a space of about 90^{cm}. Besides these, odd photographs were taken in both the first and second orders, to secure sufficient checks.

These photographs were then placed on the dividing engine previously mentioned and measured with the utmost care, each measurement being repeated several times independently. Various portions of the screw were used to eliminate errors, and the measurements were made as nearly as possible at the same temperature, so that errors due to expansion of the glass became practically inappreciable. The dispersion used was so great that one millimeter on the negative equalled 2·72 tenth-meters of wave-length, so that a small error in measuring could produce but a slight difference in the resulting wave-length. In fact, very good results could be obtained by simply measuring the photographs with an accurate scale, wave-lengths thus obtained agreeing to within one part in ten thousand. In case of each line measures were taken from both ends of the spectrum, and they agreed so closely that the probable error of the deter-

ination was in every case less than 0·1 tenth meter, and in any cases decidedly less.

The series of photographs contained about forty lines, of hich some thirty were distinct enough to admit of accurate easurement. One or two of this number were somewhat oublesome on account of being quite nebulous, particularly ie or two lines in the extreme ultra-violet. Some of the inter lines were omitted and the total number of lines accutely determined in the entire spectrum was thirty, of which e wave-lengths are subjoined. The first column contains the .lues thus obtained, while the second and third respectively ntain the values given by Hartley and by Cornu. The visle lines are included in the table.

Bell.	Hartley.	Cornu.
6438·77		
5379·22		
5338·50		
5086·09		
4800·15	4799·	
4678·39	4676·7	
4414·19	4414·5	
3611·75	3611·6	
3609·39	3609·6	3609·
3534·69	3535·0	
3466·70	3466·8	
3465·22	3465·4	3465·5
3402·68	3402·9	3401·5
3260·12	3260·2	
3251·77	3251·8	
3249·40	3249·5	3247·
3084·28	3084·3	
2979·87	2979·9	
2880·25	2880·1	
2836·45	2836·1	
2748·45	2747·7	2747·7
2572·95	2572·2	2572·3
2329·22	2329·5	
2321·14	2321·6	
2312·83	2313·6	2313·5
2288·01	2288·9	
2264·88		
2264·42	2265·9 (mean)	2265·5 (mean)
2193·98	2196·4	2194·5
2143·75	2146·8	2144·

In comparing these values it must be borne in mind that the terminations of absolute wave-length on which they are used are not the same, since the author's work is founded on e scale of Professor Rowland's photographed map. This is

based on a measure of absolute wave-length made by Mr. C. S. Pierce, which gives for D, 5896·22 against 5895·13 given by Ångström. Although the details of Pierce's work have never been published, it is without doubt far more accurate than Ångström's. Pierce's value, however, is somewhat too large. If this difference of scale be taken into account the figures are brought into somewhat better accord, though there will still remain discrepancies. From the fact that these occur in parts of the spectrum where the author's measurements were direct and particularly free from sources of error, it seems probable that many of them may be due to the unavoidable errors in working with small apparatus by a method which several sources of uncertainty tend to vitiate.

Most of the wave-lengths determined in the present research are probably correct to within one fifty-thousandth part of their respective values, and probably in no case does the error reach 0·1 tenth meter. A greater degree of accuracy can be attained only by the use of a spark apparatus powerful enough to allow one to photograph freely in the higher orders.

The photographs were all taken on Stanley instantaneous dry plates, developed by the ordinary ferrous sulphate process. The average exposure was about thirty minutes. Thanks are due to Mr. C. T. Child for efficient aid in the photographic part of the experiments.

A number of interesting points were noted during the progress of the work. The relative intensities of the lines, while they agree upon all the negatives, often do not agree with Hartley's estimates. This is probably due to the individual peculiarities of the gratings, and shows how fallacious all such estimates are liable to be unless made on the same apparatus. It was curious to note how little the sensibility of the plates decreased, even in the extreme ultra-violet. The curves ordinarily given for the sensibility of silver salts apparently depend on sunlight, and hence really represent not so much the sensitiveness of the salts employed as the intensity of the solar spectrum after absorption by the earth's atmosphere. While in photographing the solar spectrum the time of exposure increases very rapidly in the ultra-violet portion, it must have been noticed by every one who has photographed metallic spectra that there is little trouble in reaching w. l. 2000. This fact is brought out with peculiar force in the author's negatives of the superimposed spectra of the first and second orders. Taking into account the fact that the first spectrum is somewhat the brighter there is really little difference in intensity between w. l. 4800 and w. l. 2200. The maximum intensity seems to be between w. l. 4000 and w. l. 3600 and at w. l. 2200 it appears to be about half the maximum. These are of

course only rough approximations, but they are sufficient to raise some rather interesting questions.

The great resolving power of the apparatus used in these experiments resulted in the discovery of several new double lines, notably the one at w. l. 2264, of which the components are quite sharp and of about equal intensity. A negative in the second spectrum showed lines w. l. 2979·8 and w. l. 2880·2 to be also doubles, each of them having a faint component on the side of greater wave-length. And this discovery brings out a rather striking analogy. The group having wave-lengths 2979, 2880 and 2836 and the prominent group of wave-lengths 3611, 3609, 3466, 3465 and 3402 are in relative distances, character and intensity, almost precisely alike. In each the first two lines are double and in each case the fainter component has the greater wave-length.

Now turn to the spectrum of zinc. The most prominent group in the ultra-violet is a triplet of wave-lengths, 3344, 3301, 3281. And further in the ultra-violet is another group, of wave lengths 2800, 2770, 2754, closely resembling the former in arrangement. If now these be compared with the cadmium groups before mentioned, the close analogy is at once apparent. Each zinc group has an analogue in the cadmium spectrum, somewhat expanded and of greater wave-length, but very similar in grouping and general character. A photograph of the former zinc group was taken in the second spectrum which disclosed the fact that, as in the corresponding cadmium group, the two first lines were double, each with a faint component on the side of greater wave-length. Ciamician has pointed out a similarity in the visible spectra, and as the spectra are more thoroughly examined the analogy becomes all the more striking. Plot to scale these zinc lines: 6360, 4924, 4911, 4809, 4722, 4679, 3344, 3301, 3281, 2800, 2770, 2754, 2557, 2501, and the following cadmium lines, 6438, 5338, 5379, 5086, 4800, 4678, 3609, 3465, 3402, 2979, 2880, 2836, 2748, 2572, and the extraordinary resemblance between the spectra is evident. So striking is it that it can hardly have escaped notice, but the discovery of the double zinc lines noted above so emphasizes it that it is worthy of more than passing attention. The resemblance extends not only to the grouping of the lines but to those individual peculiarities that every spectroscopist knows to be almost as characteristic of certain lines as their wave-lengths. In both spectra it is analogous lines that are longest in the spark, that are reversed in the sun, and that are most persistent in dilute solutions. Certain it is, that zinc and cadmium must have some great similarity in atomic structure, and the extent and meaning of this is a subject by no means unworthy of investigation.

ART. XLI.—*Communications from the U. S. Geological Survey, Rocky Mountain Division. VII. On the Occurrence of Topaz and Garnet in Lithophyses of Rhyolite;* by WHITMAN CROSS.

(Read before the Colorado Scientific Society, March 1, 1886.)

IN this Journal for February, 1884, I described the occurrence of minute crystals of topaz in the small drusy cavities of a coarsely crystalline rhyolite from Chalk Mountain, by Fremont's Pass, Colorado.* This was then supposed to be the first published description of the occurrence of topaz in such a manner in any eruptive rock, and especially noteworthy in one of probable Tertiary age, but it has since then transpired that the beautiful garnets and the rarer associated topaz from Nathrop, Colo., which have been sold in the mineral stores of Denver for two or three years past, present a second occurrence and that published mention of the same had already been made by J. Alden Smith in the biennial "Report on the Development of the . . . . Resources of Colorado, 1881–2," p. 36. Mr. Smith mentions a dike of an eruptive rock in the Archæan on the east bank of the Arkansas river, opposite Nathrop station on the Denver and Rio Grande R. R., Chaffee Co., and says that "a large part of it is composed of cellular pumice of a light gray color. In the cavities are beautiful crystals of topaz. . . . Associated therewith are many small dark red garnets." In the Catalogue of Minerals (l. c. p. 157) topaz is mentioned "in trachyte, near Nathrop." While I had examined many small specimens from Nathrop previous to the description of the Chalk Mountain occurrence, the gangue rock was so poorly represented by them that its nature as an eruptive rock was by no means clear, and the meager and somewhat inaccurate statements of Mr. Smith escaped attention.

Last October I had opportunity of visiting the locality at Nathrop, obtaining fuller information concerning the occurrence of the rhyolite, and a suite of specimens illustrating the same, together with the contained minerals.

Mode of occurrence of the Rhyolite.—The rock alluded to by Mr. Smith occurs directly opposite the station of Nathrop, forming a ridge about one quarter of a mile in length and 200 feet in height, running parallel to the river on its eastern bank. North of this ridge and separated from it by a stream bed is a second ridge of rhyolite, of somewhat greater extent. A third and smaller ridge of the same rock occurs on the western bank of the river, near the railroad, and in this are stone quarries now in operation. The common trend of these ridges is about

*Also in Bulletin 20. U. S. Geological Survey, 1885, p. 81.

N.W.–S.E. Nearly vertical planes of contact with gneiss are shown in one or two places, but the valley alluvium surrounds the masses for the greater part. Between the first and second ridges and east of them are more or less stratified pink or whitish rhyolitic tufa beds, containing bowlders of Archæan, rhyolite, and other eruptive rocks. This tufa is no doubt geologically connected with that occurring quite extensively among the low Archæan hills on the east bank of the Arkansas between Nathrop and Salida. The rhyolite ridges themselves seem from present appearances to be short dikes.

The Rhyolite.—The rock of the ridges mentioned varies somewhat in appearance, but cavities containing topaz and garnet are common to all, though most numerous and best developed in that mass referred to by Mr. Smith, which will therefore be first described.

The greater part of the ridge in question is made up of a white or grayish, more or less banded rhyolite, which is as a rule so compact that no constituent minerals are recognizable. The banded structure is produced by the alternation of light and darker gray layers, and is occasionally emphasized by thin bands of crystalline quartz or by an equivalent of the latter in the shape of exceedingly flattened cavities, lined by crystals of the same mineral. In this portion of the rhyolite no glass is visible, but in certain places, particularly at the south end of the dike and on its eastern side, there is a development of gray pearlite, more or less cellular and usually containing round particles of a black obsidian, somewhat larger than a pea. Whether these vitreous portions are contemporaneous with the banded rock, or represent somewhat later injections of corresponding magma, could not be definitely determined, owing to the débris-covered slopes and the limited time available for their examination. It seems most likely, however, that they are merely local phases of consolidation of the same magma as the compact banded portions.

Throughout both these types of rock are numerous cavities which in many cases represent very well the peculiar vesicles first accurately described by Von Richthofen and called by him

Lithophysen.—These are more or less round cavities, partially filled by thin curved walls, which, by a concentric arrangement and an overlapping, produce rose-like forms. In the present case these folia are often not very well developed and appear as low curved projections on the outer walls. Again, a cavity may be nearly filled by a series of concentric shells. The outer walls and the leaves of the calyx-like lithophyses are usually lined by glassy quartz crystals of minute size, with prism and pyramid. The former being clearly striated, the latter showing the hemihedral forms quite evenly balanced.

The rock of the other ridges mentioned is distinctly porphyritic in structure, showing small glassy sanidines and dark smoky quartz crystals imbedded in a predominant dull gray groundmass. Small lithophyses occur in this groundmass, sometimes exhibiting a very delicate concentric arrangement of white films, which, like those of the previously described rock, are covered by small quartz crystals.

Minerals of the cavities.—The outer walls of the lithophyses, as well as the concentric shells, when present, are primarily formed of a pure white mineral which is but seldom developed in recognizable form. Sometimes a frost-like structure caused by the interpenetration of delicate blades is seen, and quite frequently round or botryoidal masses of the white mineral occur, the surface usually showing minute crystal facets. A microscopical examination of these surfaces shows the mineral to be sanidine in stout crystals of common form. Rarely, clear crystals 1 or 2^{mm} in length are developed, and then a beautiful blue color parallel to $\frac{15}{2}$-$\bar{i}$ may be detected.* In a single cavity in the porphyritic rock the feldspar assumes delicate stalactitic forms, somewhat branching at the ends and clear only at the very tips. The round feldspathic masses are often fissured in a manner clearly showing shrinkage. A silica determination upon a small quantity carefully selected, gave 66 per cent, showing that but little free quartz was included. Alumina and alkalies are also present about as in sanidine.

Upon all surfaces of feldspar, and occasionally upon garnet and topaz, are clear doubly terminated quartz crystals, often not much below 1^{mm} in length and of the form already mentioned. Although careful search has been made no tridymite has been found.

Minute opaque ore particles are very sparingly distributed through the lithophyses. Some of them are developed in tablets about $0{\cdot}5^{mm}$ across and these at least are probably to be referred to hematite. None are entirely free from dull coatings, making identification of faces difficult.

Garnet occurs in isolated crystals of a maximum diameter of about 1^{cm}, the average being $2{\cdot}5^{mm}$, of dark red color, clear and transparent, and with finely polished faces. The predominant form is that of 2–2 (211) with small facets of *i* (110). The faces of 2–2 usually show a striation parallel to the edge of *i*, due to the oscillatory combination of undetermined faces. There are also indications of another trapezohedron in which the value of *m* can be but little less than 2.

The optical properties of this garnet are anomalous. Thin sections were prepared parallel to the cube, dodecahedron and

* For fuller statements concerning this color and its cause, see Bulletin 20, U. S. Geological Survey, p. 75, 1885.

octahedron of the most suitable crystals which could be procured and the optical action seen, so far as it possesses regularity, corresponds to the observations of Klein.* The action is weak and its regularity is no doubt disturbed by the numerous inclusions of quartz at the base of all crystals.

In the porphyritic rhyolite the garnets are usually very small but perfect and possess a somewhat lighter color than in the more felsitic rock, appearing brownish red or even approaching to a cinnamon color.

In chemical composition this garnet proves to be typical *spessartite*, that is, an alumina garnet in which the lime is almost wholly replaced by manganese with some ferrous oxide. The analysis given below was made by L. G. Eakins, in the Denver laboratory of the U. S. Geological Survey. The material analyzed was of the common dark red variety from the main locality, first described, and was obtained from about 30 crystals, which were crushed and the powder carefully examined under a lens, only the transparent and perfectly pure particles being appropriated for analysis.

Sp. Gr. 4·23 at 18° C.

SiO_2	35·66
Al_2O_3	18·55
Fe_2O_3	·32
FeO	14·25
MnO	29·48
CaO	1·15
K_2O	·27
Na_2O	·21
H_2O	·44
	100·33

Topaz appears in the lithophyses of all modifications of this rhyolite, though much less abundantly than the garnet. Its crystals are prismatic, clear and transparent, either colorless, pale bluish or distinctly wine yellow, and show a fine development of all faces represented. The form is the usual one for this mineral, the faces, in order of prominence, being:

I(110), i-$\breve{2}$(120), 2(221), 0(001), 2-$\breve{i}$(021), 4-$\breve{i}$(041), i-$\bar{i}$(100), i-$\breve{3}$(130), and 2-$\bar{i}$(201).

The largest crystals which have been found (not seen by the writer), are said to have measured about one-half inch parallel to the brachy-axis, but such specimens are very rare and the average diameter is not more than one-eighth of an inch. As the prisms are attached in all positions double terminations are

* C. Klein. "Optische Studien am Granat." Nachr. v. d. k. Ges. d. Wiss. zu Göttingen, 1882, 457.

frequent. These never show any tendency to hemimorphism. The crystals occur singly as a rule, but groups are not uncommon.

In the porphyritic rock of the northern dikes the topaz occurs in very small colorless prisms, easily mistaken for quartz when not closely examined.

Concerning the color of the topaz it was noticed that nearly all of them obtained from open cavities were colorless or of the pale bluish tint, while those found on breaking open solid masses were most frequently wine-yellow. As nearly all specimens were obtained from fragments broken out by visitors, within the past two or three years, it would seem that the action of sun-light might have produced the change in color. J. Roth mentions,* while considering the changes produced in minerals by light, that von Kokscharow has noted the bleaching of deep wine-yellow topaz from the Urals, to an impure bluish white, on an exposure to sun-light, of some months' duration.

Relation to other occurrences.—The Chalk Mountain occurrence, already referred to, is analogous to the present case in that the containing rock is a rhyolite and that the topaz occurs in cavities, but in detail the instances differ. In the Chalk Mountain rock the cavities are small and show no tendency to the lithophysal structure, and sanidine is the most abundant of the associated minerals, with some quartz and a little biotite.

An occurrence in Utah seems to be much more closely related to that of Nathrop. The locality was discovered by Henry Engelmann, geologist of Capt. J. H. Simpson's expedition across Utah in 1859, and is mentioned in Dana's System of Mineralogy. Engelmann states in the report of Simpson's expedition† that the topaz crystals were found loose on the surface and that they "apparently originated from one of the trachytic porphyries in that neighborhood." He did not see any in the supposed gangue and his statement, unaccompanied by any description of the rock, has naturally been overlooked or discredited.

I am indebted to Prof. J. E. Clayton of Salt Lake City, who has visited the locality in person, for information and for specimens illustrating this occurrence.‡ The locality is about forty

* Allgemeine und chemische Geologie, Bd. i, p. 42.

† Report of Explorations across the Great Basin of the Territory of Utah, etc., by Capt. J. H. Simpson, Engineer Department U. S. Army. Washington, 1876, p. 324.

‡ Another reference to this locality upon information derived from Professor Clayton has been made by Mr. G. F. Kunz in the Geological Survey publication, "Mineral Resources of the United States, 1883 and 1884," by A. Williams, Jr., in the article on Precious Stones, p. 738. The locality is first mentioned, in a very confusing manner, as if in the Pike's Peak region; the locality is wrongly stated as west of Sevier Lake; and the date of Captain Simpson's expedition is given as 1847.

miles north of Sevier Lake and nearly the same distance W.N.W. from the town of Deseret on the Sevier River. The mountain containing the topaz ("Thomas' Range" of Simpson's Report) is isolated, in an arid region. It is about six miles long from north to south, has a flat top and precipitous slopes, and consists of a white or grayish eruptive rock, an evident overflow, with indistinct banded structure and many amygdaloidal cavities in which the topaz occurs. A small fragment of the rock, sent by Prof. Clayton, seems to be a normal rhyolite. It contains small brilliant quartz and sanidine crystals lying in a dull white matrix, much resembling the common Nathrop rock. The sanidine exhibits a delicate but distinct bluish color parallel to a plane which could not be certainly determined but which no doubt corresponds to the orthodome $\frac{1}{2}$^{5}-$\bar{i}$.

The crystal forms shown by this topaz are given by Engelmann, as follows: exhibited by all I, i-$\breve{2}$, O, 4-$\breve{i}$, 2; by most crystals, 2-$\breve{i}$, 1, $\frac{1}{2}$; by a few, 4, 2-$\bar{i}$. From an examination of a few loose crystals sent me by Professor Clayton, I can add that i-$\breve{i}$ is sometimes developed, while O is lacking entirely in a few cases.

These crystals from Utah are larger than those from Nathrop. The base of the prisms is said to be rough and imperfect, only the ends being clear. Associated minerals have not been observed and details concerning the cavities are lacking. Nearly all crystals so far found are colorless, though pinkish, wine yellow and blue crystals have been noticed.

From various statements which have come to my notice it seems highly probable that a portion of the topaz found in different Mexican localities is also derived from eruptive rock. In no case has this been actually proven, so far as I know, by the production of specimens.

This is, it is believed, the first known occurrence of garnet in cavities of rhyolite. In the list of minerals known to occur in this manner in rhyolite J. Roth* mentions quartz, tridymite, sanidine, biotite, augite and topaz, the latter from Chalk Mountain only. To this must be added garnet and fayalite. The occurrence of the latter mineral very recently described by Iddings† from the Yellowstone National Park is very similar to that of the Nathrop minerals.

The mode of formation of the topaz and garnet is not fully determinable, but it is evident that they are not secondary products, like zeolites, but primary, and produced by sublimation or crystallization from presumably heated solutions, con-

* Allgemeine und chemische Geologie, Band ii, p. 215, 1885.

† This Journal, July, 1885, p. 58. It has also been recently observed by Tenne in obsidian from Cerro de las Navajas, Mexico. Zeitschr. d. deutschen Geol. Gesellschaft, 1885, 613.

temporaneous or nearly so with the final consolidation of the rock. The lithophysal cavities seem plainly caused by the expansive tendency of confined gases or vapors, while the shrinkage cracks in the walls and white masses of the Nathrop rock suggest the former presence of moisture. Certainly the history of the lithophyses themselves embraces that of both topaz and garnet.

Composition of the rhyolites containing topaz.—Below are submitted quantitative analyses of the only rhyolites known to contain topaz in the manner described. Under I is given the analysis of the Chalk Mountain rhyolite or nevadite, by W. F. Hillebrand; under II that of the denser Nathrop rock, and under III that of the Utah rhyolite,—both by L. G. Eakins. Analysis III was made upon the small fragment above described, which was sent me by Prof. Clayton, as typical of the occurrence.

	I.	II.	III.
SiO_2	74·45	69·89	74·49
Al_2O_3	14·72	17·94	14·51
Fe_2O_3	*none*	0·39	0·57
FeO	0.56	0·52	0·32
MnO	0·28*	0·23	*trace*
CaO	0·83	*trace*	1·03
MgO	0·37	0·14	*trace*
K_2O	4·53	4·38	4·64
Na_2O	3·97	4·21	3·79
Li_2O	*trace*	*trace*	*trace*
H_2O	0·66	2·07	0·64
P_2O_5	0·01	*trace*	
	100·38	99·77	99·99

From the above it is seen that the three topaz-bearing rhyolites agree quite remarkably in composition. They are all silica-alumina-alkali rocks, other constituents being present in almost insignificant quantities. It is however by no means a rare composition which is possessed by these rocks. The examination of the rhyolites of the Great Basin, near the 40th parallel, by the chemists of the King Survey showed several rocks closely allied to these in composition and similar ones have been described from other parts of the western United States and from Europe.

* As MnO_2 in this rock.

ART. XLII.—*On the Strain-effect of Sudden Cooling exhibited by Glass and by Steel*;* by C. BARUS and V. STROUHAL.

Introductory.—In the foregoing number of the Journal we communicated a series of results on the structure of steel of a given kind, tempered hard. They showed, in general, that from the circumference to the axis of a quenched non-fileable steel cylinder, hardness continually diminishes; that the first fileable strata are encountered at a distance of about 1^{cm} below the surface. Moreover, as hardness decreases, the density of the elementary conaxial cylindrical shells increases and in proportion as the layers become more and nearly or easily fileable the density is found to approach the density of soft steel. From an examination of rods of different diameters (2^{cm} to 3^{cm}) it appears, steel of a given kind presupposed, that the hardness at a point is essentially dependent on the distance of the point below the surface. The rate at which sudden cooling takes place must be similarly conditioned. Hence it is permissible to associate the one phenomenon with the other and to state that the hardness in a given point below the surface is dependent on the rate at which cooling there takes place. This point of view is suggestive: structure investigations may be made to furnish us the best means we know for the comparison of hardness and rate of cooling.

The results cited apparently make sad havoc with physical theories of temper. They seem indeed to be fatally at variance with the usually accepted views, viz: that in hard tempered steel an abnormally dense shell is arched around an abnormally rare core, the two states of strain mutually conditioning each other. The data may even be looked upon as furnishing evidence sufficient to prove the total absence of strain. It is the object of the present paper to investigate in what measure this evidence is critically sufficient; if it be insufficient, to state the nature and relations of the strain-effect of quenching somewhat more clearly than we were able to do in our earlier work.

In our little book on the iron-carburets† we endeavored to contrast the respective merits of chemical and physical theories of temper, using for this purpose all the data known to us, as well as special results of our own. This deduction seemed warranted, that hardness and strain are distinct and separate properties of a tempered iron-carburet;‡ that they need not necessarily coexist. Leaving therefore hardness pure to be ex-

* Communicated with the permission of the Director of the Geological Survey.
† Bull. U. S. Geolog. Survey, No. 14, 1885, p. 76. ‡ Ibid., p. 103, 197.

plained chemically, we inferred that the category of electrical and magnetic phenomena exhibited by steel on passing from hard to soft are mainly referable to changes in the character and intensity of the strain which the tempered rod carries. We accepted the theory of a dense shell and rare core as being the most satisfactory and elegant conception of the strain in question,—with the proviso* that "it must be regarded as a mere *diagram* of the essential features of the vastly more complicated structure of the glass-hard rod." These conditions premised we finally interpreted all variation of strain produced by annealing as the combined effect changes of the viscosty of steel due to temperature and of interference of thermal expansion with the said strain.

The experimental question which we are endeavoring to elucidate may therefore be succinctly put as follows: 1. With what degree of sensitiveness do the variations of the density of the rod as a whole, indicate the corresponding variations of strain. 2. Is it possible successively to remove layer after layer of a rod without materially changing the character and intensity of the strain which the rod is supposed to carry. 3. In how far does the actual structure of tempered steel differ from the diagrammatic distribution of density above assumed. 4. Does the process of sudden cooling impart strain alike in kind† but differing enormously in degree to all substances. In our paper on structure we had the second and third of these points principally in mind. We were unable to obtain direct and decisive evidence of the occurrence of shrinkage during the removal of shells from a hard steel rod. But since the structure of steel differs so largely with the kind of steel operated upon we do not regard our experiments as made in sufficient number to be conclusive. An examination of the density of the elementary shells shows that the character of the density at any point regarded as a function of the distance of the point below the surface, is harmonic.‡ To investigate this relation it is unfortunately necessary to make the measurements for thin ($\frac{1}{2}^{\mathrm{mm}}$) shells. Hence the mean amplitude of vibration and the limits of the unavoidable errors of observation are of the same order. To discriminate between the periodic effect of temper, which may show regular or irregular periodicity, and the apparently periodic distribution of mere errors of observation is difficult and requires very nice and careful observation. In the Bulletin (35) cited we attempt to arrive at this discrimination by making minute comparisons of the structures of rods of the same kind of steel, and of the same or of different diameters. This pro-

* Bull. U. S. Geol. Survey, No. 14. p. 96; ibid., pp. 95 to 98.

† We do not necessarily refer to mere volume expansion here. See Wrightson. Journ. Iron and Steel Inst., ii. 1879, p. 418.

‡ This volume. p. 386.

cedure is excessively laborious, for it calls for a detailed construction of the relation of the density and the position of the points along any given radius of the rod and subsequent examination of the properties which the divers diagrams have in common. We have gathered many data, but the work is as yet incomplete, and the reader desiring further information will have to be referred to the Bulletin, where the whole subject is discussed. Experiment on the fourth of the above topics we have now in progress and shall publish later. This narrows the purposes of this paper to the consideration of the first and most important of the above points, viz: in what degree the density of a hard steel rod at different points, even when measured with all attainable accuracy, is sufficiently sensitive to represent the character, relations and intensity of the temper-strain.

Density and Resistance (Strain) of Tempered Steel.

Experimental results.—The discussion may be appropriately commenced by an examination of the variation of density of steel successively annealed from hard to soft. Our experiments on this subject, made in some number, are detailed in Bulletin No. 27, now in press, and for this we select the following digest. The table (I) contains data for length, diameter and temper; temper being expressed by the temperature and time at which the divers glass-hard rods were annealed. The table furthermore contains the specific resistance, (s_0), at 0° C., in microhms, referred to the centimeter cube; the density (Δ_0) and the volume (v_0) per unit of mass (g) for the same temperature, 0°. In the cases of rods Nos. I and II, density was measured in the ordinary way. The other values of Δ_0 are derived from very painstaking pycnometric measurements, all of which were made at least in duplicate and are warranted to two or three units of the third decimal. Values for resistance which could not be obtained by direct measurement were supplied by interpolation from our earlier researches. All such data are put in parentheses. Parentheses also enclose certain values for the temperature of the annealing furnace to show that they are derived by interpolation from the known power of the furnace under given circumstances. The other temperatures are measured in a way to be indicated elsewhere. The greatest care was taken to so anneal the rods as to *exclude* all errors due to superficial *oxidation or carburation.*

Table I.—*Electrical resistance, density and specific volume of steel, when varying with temper.*

No.	Length.	Diameter.	Temper.	s_0.	Δ_0	v_0
	cm	cm		Microhm		
I	5·3	1·9	Commercial, soft	(15)	7·8372	0·12760
			Glasshard	(44)	7·8092	0·12805
			Annealed, 100°, 1^h	(39)	7·8088	0·12806
			" 100°, 4^h	(37)	7·8094	0·12805
			" 100°, 8^h	(36)	7·8108	0·12803
			" 100°, 12^h	(36)	7·8114	0·12802
			" 200°, 30^m	(28)	7·8096	0·12804
			" 330°, 5^m	(21)	7·8236	0·12782
			" 620°, 5^m	(18)	7·8342	0·12765
			" 805°, 30^m	(17)	7·8361	0·12762
			" (1300°)	(19)	7·8465	0·12744
II	10·11	0·576	Commercial, soft	(16)	7·7033	0·12981
			Glasshard	(44)	7·6200	0·13123
			Annealed, 190°, 4^m	(32)	7·6542	0·13065
			" 330°, 2^m	(21)	7·6661	0·13044
			" 645°	(18)	7·7008	0·12986
			" 830°	(18)	7·7170	0·12958
			" (1300°)	(19)	7·7392	0·12922
55 to 60	21 pieces,	0·127	Commercial, soft	15·25	7·7337	0·12931
61 to 63	each about	0·127	Glasshard	43·29	7·6688	0·13040
	$2\frac{1}{2}^{cm}$ long.		Annealed, 100°, 9^h	35·61	7·6976	0·12991
			" 200°, 2^m	33·11	7·6981	0·12990
			" 200°, 30^m	28·76	7·7030	0·12982
			" 330°, 30^m	20·61	7·7215	0·12951
			" 810°, 30^m	18·10	7·7872	0·12842
			" (1000°)	19·74	7·7865	0·12843
			" (1400°)	19·29	7·8007	0·12819
O	18 pieces,	0·226	Commercial, soft	(15)	7·81	0·1260
	each about		Glasshard	(44)	7·6817	0·13018
	$2\frac{1}{2}^{cm}$ long.		Annealed, 100°, 10^m	(42)	7·6943	0·12997
			" 100°, 7^h	(37)	7·7102	0·12970
			" 190°, 15^m	(31)	7·7251	0·12945
			" 330°, 8^m	(21)	7·7441	0·12913
			" 4[illegible]0°, 1^h	18·27	7·7641	0·12880
			" 720	17·13	7·7793	0·12854
			" (900°)	18·10	7·7840	0·12846
			(1000°)	18·60	7·7865	0·12843
			" ([illegible]300°)	18·30	7·7856	0·12801
30 to 36	72 pieces	0·081	Commercial, soft	16·27	7·7268	0·12942
	about	0·081	Glasshard	43·86	7·6547	0·13064
	$2\frac{1}{2}^{cm}$ each		Annealed, 100°, 1^h	39·26	7·6666	0·13044
			" 100°, 13^h	35·51	7·6745	0·13030
			" 190°, 4^h	30·82	7·6841	0·13014
			" 190°, 4^h 30^m	27·10	7·6808	0·13020
	71 pieces*		" 190°, 4^h 30^m	27·10	7·6848	0·13030
			" 330°, 10^m	20·68	7·6806	0·13020
			" 470	18·36	7·7190	0·12955
			" 530°	18·17	7·7227	0·12949
			" 690°	17·24	7·7272	0·12941
			" 810°	17·56	7·7586	0·12889
			" 1000°	18·59	7·7705	0·12869
			" †1100°	....	....	....

* One piece lost.

† Fusion of copper envelope (capsule) destroys the wire.

Discussion.—It is not our object to enter into a full discussion f these results here. We merely advert to the fact that hereas density increases continually on passing from hard to oft, resistance passes through a pronounced minimum.

Whether we regard Δ_0 as a function of s_0 or of the tempera- ure t° at which the rod was annealed, the relations contained n the table lead to an important inference, with an immediate earing on our present purposes. It appears plainly that *the nnealing of a rod successively from extreme hard to extreme soft loes not exhibit the characteristics of a single and homogeneous henomenon.* This annealing presents two distinct and inde- endent phases which merge into each other when t° corre- ponds to incipient redness. A graphic representation of Δ_0 arying with t° shows this transition with singular clearness. Between $t=200^\circ$ and $t=500^\circ$, all the loci pass through two onsecutive circumflexures in such a way as to change the eneral and pretty uniform contours of concavity downwards, nto convexity downwards for the interval in question. The livision of the complete phenomenon into two parts being thus uggested, we find on further inspection that the variations of he electrical constants of temper subside almost completely ithin the first of these parts (annealing between 0° and 350°); hereas in the second part (annealing between 350° and 1000°) hey became crowded and complex. It follows plausibly and t once that during the first of the phases under consideration e encounter the subsidence of a mechanical strain. This nference gains much in weight when we find that this strain van- shes in the way peculiar to phenomena of viscosity, at a slowly ecreasing rate, through infinite time.* In the second phase, nechanical and chemical occurrences are superimposed and the bove results do not enable us to disentangle them.

The final important deduction from the data is this, that dur- ng the first phase in which the larger values of resistance are rom two to three times the smaller values, the variation of ensity is slight. In the second phase we encounter large vari- tions of density associated with small variations of resistance. These curious relations characterize the phenomenon as a hole. We shall interpret them partially at least below.

Density and Strains in Tempered Glass.

Experimental results.—This result substantiates the evidence n favor of the existence of strain in hard steel, adduced in our arlier papers.† Beyond this it shows almost conclusively

* In other words the temper strain vanishes just like the simple "drawn" rain imparted by the wire plate, while the wires carrying them are each exposed the prolonged action of temperature.—Bull. 14, p. 93.

† Bull. 14, pp. 88 to 103.

that the density-effect of the annealing of hard steel is out of all proportion and symmetry with the strain effect and the corresponding electrical effect. We were desirous therefore of studying the temper-strain in substances other than steel and free from carbon. Long ago, glass had suggested itself to us for this purpose.* We communicate in the following Table II the density effect produced by successive annealing of ordinary Prince Rupert drops. Twelve of these were in hand. Three were broken to test the strain, the remainder examined. All the drops contained included bubbles, one or more, often $0{\cdot}2^{cm}$ to $0{\cdot}3^{cm}$ in diameter and distributed irregularly. Usually a few large bubbles predominated. The drops moreover showed a purple coloration, which disappeared after annealing at incipient redness.† To anneal the drops at different temperatures we enclosed them in a test-tube, cushioned upon and surrounded by carded asbestos. The end of the tube was submerged sufficiently to cover the P. R. drops in boiling camphor, mercury, sulphur, etc., as given in the table. To anneal at red heat, the drops were suspended in little baskets of platinum foil, in the center of large thick clay crucible and then heated to the desired temperature in an assay furnace. Under all circumstances but one, care was taken to cool the drops slowly. Table II contains under "temper" the temperature and time of annealing, not including the time of cooling, however. The column m gives the weight of each drop in grams. Variations of m are due to accidental breakage of the frail stems of the drops. Where no such breakage occurs m is constant. $\varDelta_0$, finally, is the density of the drops at 0° C., under the conditions given. Each $\varDelta_0$ is the mean of two independent determinations and is warranted correct to within one or two units of the third place.

Table III following is constructed to facilitate a comparison of the important data. The second and third columns contain the densities of the extreme states of temper, the original quenched, "hard," and the final "soft" or thoroughly annealed state. The remaining columns contain the increments of density due to quenching, relative to the density of the soft state, the relative increments in other words which are retained at the divers temperatures given.

* Wied. Ann., vii, p. 406. 1879.

† The color of the drops is amethystine; the powdered glass pink.

Table II.—*Temper, weight and density of quenched glass (Prince Rupert's drops), successively annealed.*

No.	Temper.	m.	Δ_0	Remarks.
		g.		
1	Quenched	1·3500	2·4345	Bubbles. Color.
	Annealed, 360°, 30m (Mercury)	1·3500	2·4401	Do.
	Annealed (650°), 10m	1·3497	2·4901	Bubbles and color vanish. Form of drop not changed. Cooled slowly.
	Annealed, red heat	1·3470	2·4910	Cooled slowly.
	Annealed, red heat	1·3311	2·4883	Cooled *in air*, from intense redness.
	Annealed, red heat	1·3312	2·4915	Cooled slowly
2	Quenched	1·3200	2·4364	Bubbles. Color.
	Annealed, 360°, 30m (Mercury)	1·3200	2·4408	Do.
	Annealed (650°), 10m	1·3191	2·4903	Bubbles and color vanish. Form of drop not changed. Cooled slowly.
	Annealed, red heat	1·3172	2·4912	Cooled slowly.
3	Quenched	1·4590	2·4374	Bubbles. Color
	Annealed, 200°, 15m (Paraffine.)	1·4591	2·4364	Do.
	Annealed, 360°, 30m (Mercury.)	1·4590	2.4411	Do.
4	Quenched	1·3305	2·4356*	Bubbles. Color.
	Annealed, 200°, 15m (Paraffine)	1·3305	2·4351	Do.
	Annealed, 360°, 30m	1·3292	2·4383	Do.
5	Quenched	1·3009	2·4349	Bubbles. Color.
	Annealed,* 200° 1h 30m (Camphor.)	1·3009	2·4359	Do.
	Annealed, 360°, 1h (Mercury.)	1·3010	2·4402	Do.
	Annealed, 450°, 30m (Sulphur.)	1·3012	2·4446	Do.
	Annealed (550°), 10m	1·2983	2·4531	Color vanishes. Cooled slowly
	Annealed, red heat	1·2982	2·4914	Bubbles gone. Form partially changed.
6	Quenched	1·4409	2·4323	Bubbles. Color.
	Annealed,* 200°, 1h 30m (Camphor.)	1·4409	2·4333	Do.
	Annealed, 360°, 1h (Mercury)	1·4409	2·4382	Do.
	Annealed, 450°, 30m (Sulphur)	1·4412	2·4422	Do.
	Annealed (550°), 10m	1·4410	2·4534	Color vanishes. Cooled slowly
	Annealed, red heat	1·4408	2·4893	Bubbles gone. Form partially changed. Slow cooling.
7	Quenched	1·4795	2·4395	Bubbles. Color.

* An explosion of the camphor vapor may have slightly raised these values, but we believe them to be correct.

No.	Temper.	m.	Δ_0	Remarks.
8	Quenched	1·0025	2·4395	Bubbles. Color.
	Annealed, 360°, 30^m (Mercury.)	1·0025	2·4444	Do.
	Annealed, 360°, 3^h (Mercury.)	1·0023	2·4482	Do.
	Annealed, 450°, 1^h (Sulphur.)	1·0023	2·4526	Do.
	Annealed, 450°, 4^h (Sulphur.)	1·0023	2·4586	Do.
	Annealed, red heat	0.9982	2·4901	Bubbles and color gone. Form partially changed. Cooled slowly.
9	Quenched	1·2759	2·4365	Bubbles. Color.
	Annealed, 360°, 30^m (Mercury.)	1·2745	2·4423	Do.
	Annealed, 360°, 3^h	1·2745	2·4436	Do.
	Annealed, 450°. 1^h	1·2745	2·4472	Do.
	Annealed, 450°, 4^h	1·2727	2·4510	Do.
	Annealed, red heat	1·1592	2·4929	Bubbles and color gone. Form partially changed. Cooled slowly.

TABLE III.—*Density of Prince Rupert's Drops, Quenched and Annealed. Digest.*

No.	Hard. Δ_0.	"Soft." Δ_0.	Density-increment relative to "soft," when annealed at 20°	200°	360°	450°	(550°)	(650°)	Red heat.
			—0·0	—0·0	—0·0	—0·0	—0·0	—0·0	
1	2·4345	2·4915	229	....	207	....	....	006	—0·0002
2	2·4364	2·4912	222	....	202	....	....	004	—0·0000
3	2·4374	.....	216	220	201	....	....	....	......
4	2·4356	.....	223	225	212	....	....	....	......
5	2·4349	2·4914	227	223	206	188	154	....	—0·0001
6	2·4323	2·4893	229	225	205	189	144	....	+0·0007
7	2·4395	.....	207	...	....	....	....	....	......
8	2·4395	2·4901	203	....	184 168	150 127	....	....	+0·0004
9	2·4365	2·4929	227	....	203 198	184 168	....	....	—0·0007

Discussion.—The salient features of these data are obvious from an inspection of Table III. The density-effect of quenching is decidedly *negative;* the increase of specific volume is exceptionally large. Moreover, the nine Prince Rupert drops examined exhibit nearly the same initial density, and nearly the same final density. The approximate equality of the values Δ_0 for the soft state is easily explained. They indicate that in proportion as we bring the strain to vanish, we reach the normal density of the glass. Not so easy is it to account for the observation, that the density of the Prince Rupert drops shows almost the same degree of equality in the hard (quenched) state. Indeed, if we take the fact into consideration that the drops invariably contain *bubbles* distributed irregularly and without apparent relation as regards size and number, the difficulties of explanation are increased. In other words the remarkable result that the volume-increase due to quenching is quite as much the same for all drops as is at all possible for the case of so complicated an operation, is an exceedingly striking and important result and leads to this inference: Inasmuch as bubbles are present in like total volume in each of the drops, their presence can not be a circumstance of mere accident; they must be regarded as a normal effect or, better, a necessary result of the operation of quenching applied to glass: they must in some very intimate way be connected with the strain which the glass globules have experienced in virtue of sudden cooling.

Retaining this very plausible surmise in mind, we proceed to a more minute inspection of the effect of annealing the hard Prince Rupert drops. We obtain results very similar to those investigated above for steel. The density effect of annealing is decidedly positive, and is greater as temperature and time of exposure are increased. Again, we readily divide the physical effect of annealing into two parts or phases. The first of these corresponds to the annealing temperatures 0° to 500°, the other to higher temperatures. The range of temperatures corresponding to the first phase is therefore larger for glass than for steel; and if we compare Tables I and II it appears obviously, that for like density effects the annealing temperatures must be chosen higher in the former case (glass) than in the latter. But the change of density encountered in both instances is small; and yet in spite of the small density-effect during the inferior stage of annealing, by far the greater intensity of strain vanishes. The drops after annealing at 200° are still explosive; if they be broken after having been annealed in boiling sulphur (450)° they are found to have lost all traces of the explosive properties which the originally quenched drops possessed.

Professor Rood* informed us that the polarization figures could be quite wiped out by annealing such ordinary glass as exhibited them only as far as the temperature of melting zinc. We infer that at the end of the first phase of annealing we have in hand a hollow glass globule practically free from strain.

During the second phase of the annealing phenomenon (500° to 1000°), we observe a very pronounced change of the density of the Prince Rupert drops, corresponding to the above result for steel. But the explanation is here readily at hand: at incipient redness the enclosed bubbles *disappear* or are reduced to mere specks. The large increment of density in question is therefore nothing more than an expression for the collapse of the viscous hollow globule in virtue of atmospheric pressure. This important observation enables us to interpret all the phenomena of annealing satisfactorily. It must therefore be carefully examined.

We will endeavor to prove that the bubbles are vacua; that they are not accidental inclusions of gas or aqueous vapor. The temperature from which glass is quenched is certainly less than 1500°. The temperature at which glass is sufficiently viscous to yield easily to atmospheric pressure is certainly greater than 500°. Suppose now that the changes of volume of the bubble were the result of thermal expansion of an included gas. Let v_{1500} and v_{500} be the volumes of the gaseous inclusion at 1500° and 500°, respectively, under normal pressure. Let v_h and v_s be the volumes of the (gas) bubble for the quenched-hard and annealed-soft states. Then we deduce, *a fortiori*,

$$\frac{v_h}{v_s} < \frac{v_{1500}}{v_{500}} = 2 \cdot 3 \tag{1}$$

with this as a point of departure the following little digest, Table IV, of mean results has been prepared. Here m is the mean mass of all the drops examined; Δ_h, Δ_s, V_h, V_s, their mean density and total volume for the hard and the soft states, respectively; v is the mean volume, r the equivalent mean radius of the bubbles. In the second horizontal row V_h has been diminished one-half per cent to refer all volumes to the beginning and end of the second phase of annealing.

* Results obtained by Professor Rood during his experiments with high vacua.

TABLE IV.—*Mean volume relations of the Prince Rupert drops and of the hypothetical gas-bubble.*

V_h	V_s	v at 1500°	v at 500°	r at 1500°	r at 500°	
cc.	cc.	cc.	cc.	c.	c.	
0·5454	0·5334	0·0120	0·0052	0·142	0·107	$\frac{v_h}{v_s}<2{\cdot}3$
0·5427	0·5334	0·0093	0·0041	0·130	0·099	$\frac{r_h}{r_s}<1{\cdot}3$

Mean $m = 1{\cdot}3288$ g
"Hard:" Mean $\Delta_h = 2{\cdot}4363 \pm 0{\cdot}0008$
"Soft:" Mean $\Delta_s = 2{\cdot}4911 \pm 0{\cdot}0016$

Inasmuch as the values v_{500} and r_{500} are inferior limits, it is clear that if the bubbles were gas or vapor, they would be of the same order of visibility before and after annealing. In other words, if the bubbles were gas, casual inspection would not detect a difference of their size in the hard-quenched and in the "soft" drops. In the experiments, however, the bubbles all but vanish. Hence they can not be gas.

To obtain additional assurance on this point we ground flat faces on the annealed drops, Nos. 1, 5 and 8, and then measured the size of the inclusions. We found these values:

No. 1: $v_s = 0{\cdot}000037$ c. c.
No. 5: $v_s = 0{\cdot}000062$ c. c.
No. 8: $v_s = 0.000040$ c. c.
Mean: $v_s = 0{\cdot}000046$ c. c.

From actual measurement therefore we find,

$$\frac{v_h}{v_s} > 100 \qquad (2)$$

a result wholly incompatible with $\frac{v_h}{v_s} < 2{\cdot}4$ as derived above (Table IV). It follows conclusively that the bubbles are not accidental gas inclusions; that only an insignificant part of the variations of volume produced by quenching can be referred to thermal expansion of gas.

If the gas were aqueous vapor, and if dissociation were complete, then the upper limit of (1) would have to be increased in the ratio of 3 : 2. This does not remove the discrepancy between (1) and (2). Moreover, since dissociation of water is only incipient at 1500° and is not even complete at the temperature of melting platinum, the volume variation of the bubbles can not be due to the presence of water in the bubbles.

If on the other hand we endeavor to explain the bubbles as vacuities* left by the contracting glass, we arrive at accordant and plausible results. Let t be the temperature to which the

* Very analogous to Torricellian vacua.

homogeneous glass drop must be heated in order that the observed mean volume of the soft state may be equal to the observed mean volume of the hard state. Then

$$t < \frac{1}{3\alpha} \frac{\Delta_0 - \Delta_t}{\Delta_t} \tag{3}$$

where α is the ordinary coefficient of linear expansion of glass. By inserting the values of Table III into (3) we derive

$$t < 900°.$$

In other words the quenched globule has retained the volume which the hot glass possessed at a temperature certainly smaller than 900°. This result taken together with the other is conclusive.

The general result of our investigation on the process of sudden cooling, therefore, points out the fundamental importance of a rigid shell. As the material (glass or steel) cools, contraction as a whole takes place not centripetally but centrifugally, i. e., not towards the center of figure but away from it. So long as the interior remains liquid or viscous, the result is simple separation, commencing at points where minute air bubbles may preëxist,* rather than at points of the continuity of glass. The final result is a vacuum bubble such as we have observed it. In proportion as the interior becomes rigid, the temper strain appears. Should the glass hold gases in solution, they would tend to escape into the vacua in question. There is probably another reason why in most instances the bubbles cannot be brought completely to vanish.

Annealing reverses the whole phenomenon. The small changes of density observed in the first phase may be easily accounted for; it is probable that during these stages of annealing the re-arrangement of molecules and disappearance of strain is accompanied by expansion inward, toward the vacua. Hence the incommensurately small variation of mean density which accompanies the great optical effects (glass), and the great electrical effects (steel).† During the second stage of annealing, again, the density-effect is incommensurately large; for glass it is the expression of a mere collapse due to atmospheric pressure. At all events the density-effect (error) due to bubbles quite swallows up the density-effect due to strain. Hence to represent the true relation of density and resistance or of density and annealing temperature in case of steel, it may be necessary to lower the part of the curves corresponding to the second place of annealing by amounts equivalent to the bubble

* P. R. drop No. 1, heated intensely in a blast lamp and cooled in air shows a decrement of density. This is due to the rapid cooling. For when this drop is heated and cooled in the crucible, density is again incremented. The experiment shows the tendency of glass to retain strains. During the heating to 1000° no expansion of the very small bubbles was observable.

† The electrical and optical criteria may be considered equally sensitive.

or fissure discrepancy, or else for like reasons to raise the parts of the curves corresponding to the first phase. If this be done the circumflexures become less pronounced or disappear, and the points for the commercial soft state are more easily referred to the curves to which they belong. If, therefore, allowance be made for the distortion due to internal sensible pores, the relations become more uniform.

It is interesting to observe that glass retains the volume-expansion corresponding to a temperature somewhat below 900°; whereas steel retains the volume-expansion of a temperature below 400°. Similarly the strain in steel is very perceptibly affected by annealing temperatures as low as 50°, whereas for glass the perceptible annealing effects are only incipient even at 200°. The amount of strain retained is, *cæt. par.*, not merely a function of the viscosity of the material subjected to quenching. It must depend also on the heat conductivity of this substance. For instance, if like figures of glass and of steel be quenched alike, then at the same time and depth the thermal gradient would be much steeper in the case of glass than in the case of steel. Hence, *cæt. par.*, during quenching a rigid shell is possible in the case of glass for higher temperatures of the core than in the case of steel. The sudden contraction of the shell pressure has a marked effect on the melting point or degree of fluidity of the core. But it is best to waive this observation here, for the want of data to interpret it.

We have finally to consider the bearing of the results of this paper on the structure of steel. The detailed similarity observed in the annealing of glass and of steel suggest the inference that the interior of hard steel may be sensibly fissured. Under all circumstances the diagrammatic structure of dense shell and rare core would be inaccurate to the extent in which these fissures are irregularly distributed. Hence the difficulty of developing the true character of the dependence of the density (δ) at any point upon the distance of this point below the surface. We are able to account in part for the quasi-harmonic relations obtained both by Dr. Fromme* and by ourselves.† While the consecutive shells are being removed by solution, periodic fluctuation of δ must result whenever fissures are invaded. If, furthermore, we take into consideration that the density effect of even great intensities of temper-strain is small, it appears that the true nature of the strained structure of tempered steel may be beyond the discernment of the density-method of investigation, altogether. The *gross* variation of density along the radius is a carburation phenomenon.

Retrospective.

In our earlier work on steel we adverted to the singular co-

* Wied. Ann., viii, p. 356, 1879. † Bull. 35. This volume, p. 386.

incidence of the resistance increments corresponding to like volume increments, no matter whether the latter be the result of temper or of temperature. The light which the new data throw upon the internal condition of tempered steel—the tendency to a fissured structure—shows, however, that this material is not as well adapted for the quantitative evaluation of the *true* relation between volume and resistance, as we supposed. So long, moreover, as the meaning of the minimum resistance and of certain carburation phenomena encountered during annealing at red heat remains obscure, it is safest to give the said relations no more than qualitative importance. The best means to the end in question is probably to be sought for in the compression of mercury.

With this unimportant exception, the present results have materially substantiated our earlier views at every essential point. Hence we infer as before that "the annealing of steel, considered physically, is at once referable to the category of viscous phenomena. In the ordinary cases of viscosity measurements, the phenomenon is evoked by sudden application of stress (torsion, flexure, tension, volume-compression, etc.) under conditions of constant viscosity; in the case of annealing by sudden decrease of viscosity under conditions of initially constant stress. Thermal expansion interferes with the purity of these phenomena by destroying the conditions of existence of the strain which accompanies hardness, and this in proportion as the expansion is greater."* Again, irrespective of the manifestation of mere hardness, "the existence of the characteristic strain in glass-hard steel is the cause of electrical effects so enormous, that such additional effects which any change of carburation may involve may be disregarded and the electrical and magnetic results interpreted as due to variations in the intensity of the said strain."†

This deduction applies of course to the first phase of the phenomena of annealing, since it is within these limits that the strain in question is brought to vanish. With these results in hand we may proceed justifiably toward a study of the question, whether the conditions for the permanent retention of magnetism in an iron-carburet are not the identical conditions for the permanent retention of any strain. If we select the temper-strain for comparison, we do it not merely because our experience has familiarized us with this strain, but because of the clear-cut beauty of its manifestations, and because of the simplicity and pronounced character of the functions which describe it.‡

Washington—Prague, April, 1886.

* Bulletin, U. S. Geolog. Survey, No. 14. p. 196. † Ibid., p. 97.

‡ We desire to remark that the principal inferences of this paper have since been substantiated by polariscopic evidence, and by an investigation of the density of the consecutive shells of the P. R. drop. These results will be given in our next paper, nearly ready, May, 1886.

ART. XLIII.—*Upon the Origin of the Mica-Schists and Black Mica-Slates of the Penokee-Gogebic Iron-Bearing Series;* by C. R. VAN HISE.

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THE iron-bearing formation of the Penokee-Gogebic region has been traced from Lake Numakagon in Wisconsin to Lake Gogebic in Michigan, a distance of more than 80 miles. The rock belts of this series traverse the country in a general east-and-west direction. They dip quite uniformly to the northward at an angle usually ranging from 60° to 70°, though occasionally the dip is at a lower angle. They lie unconformably upon a series of schists, gneisses and granites, and are overlain unconformably by the Keweenaw Series.†

At Penokee Gap, Wisconsin, the series is, in round numbers, 13,000 feet thick, of which the upper 11,000 feet are mica-schists and black slates,‡ which thickness is retained to the eastward until Michigan is reached. These upper members have been traced continuously from English Lake (chiefly in Secs. 5 and 8, T. 44 N., R. 3 W., Wis.) to the Black River (Sec. 12, T. 47 N., R. 46 W., Mich.), a distance of more than 40 miles, their course in this distance being north of east, in places as much as 30° north of east (see map).§

The present lithological condition of the upper members of the formation is quite diverse in different localities. The group comprises fine-grained, crystalline mica-schists, black mica-slates, greywackes,‖ greywacke-slates and quartzites. The exposures at the eastern extremity of the belt at Black River are red and white feldspathic quartzites. As we proceed westward the exposures found show chloritic greywackes and greywacke-slates. In section 14, T. 46 N., R. 2 E., Wis., the exposures

* In advance of a full treatment of the subject to be included in a memoir on the Penokee-Gogebic Iron-Bearing Series, by R. D. Irving and C. R. Van Hise.

† This Journal, March, 1885. Divisibility of the Archæan in the Northwest, by R. D. Irving.

‡ Geol. Wis., vol. iii, p 105.

§ The accompanying map is taken from the article before referred to. For discussion of stratigraphical relations and geographical distribution of the Penokee-Gogebic Series, see the same article, also Geol. Wis., vol. iii, pp. 100–166.

‖ The term greywacke is here used in a lithological sense, in accordance with the definition of the term given by Geikie, Text Book of Geology, 2d ed., p. 162: "A compact aggregate of rounded or subangular grains of quartz, feldspar, slate, or other minerals, or rocks, cemented by a paste which is usually siliceous, but may be argillaceous, feldspathic, calcareous or anthracitic. Gray, as its name denotes, is its prevailing color; but it passes into brown, brownish purple, and sometimes, where anthracite predominates, into black. The rock is distinguished from ordinary sandstone by its darker hue, its hardness, the variety of its component grains, and above all by the compact cement in which the grains are imbedded."

show biotitic and chloritic greywackes. Continuing westward, the rocks become more and more micaceous, and at Penokee Gap, Wisconsin, they are mostly mica-schists and black mica-slates, although narrow belts of micaceous greywacke are yet found; while the schists at English Lake taken by themselves would probably be considered completely crystalline rocks—as completely crystalline as some mica-schists in the older gneissic formation. These rocks, at present of such widely varying character, microscopic study shows to have been originally in essentially the same condition. All were once, as some are still, completely fragmental rocks composed chiefly of quartz and feldspar, mingled in places with a little clayey matter, perhaps also with a small quantity of fragmental mica and some ferrite. The fragmental feldspar is or was very largely orthoclase, although plagioclase is usually, and in certain localities quite plentifully, found. Measurements of its extinction angles show this plagioclase to be of an acidic character, and it is probably in great part oligoclase. The proportions and magnitudes of the fragments of quartz and feldspar vary in different localities. The quantity of feldspar was apparently considerably greater in the rocks of the western part of the area than in those of the eastern part, i. e., was greater in those rocks which are now mica-schists and mica-slates than in those which have formed the kinds to which the name greywacke is here applied.

As far as the quartzites, greywackes and greywacke-slates are concerned the microscope shows that they reached their present conditions by processes already fully described by Irving and myself.* Briefly summarized, these processes included: secondary enlargement of the quartz fragments and in a few cases apparently of the feldspar fragments also; the deposition or formation *in situ* of interstitial finely crystallized quartz; and a chloritic replacement of the feldspars, with consequent separation of silica. In general, the processes by which the mica-schists and black slates have reached their present condition are much the same as the above, with the very important difference that the feldspars instead of altering to chlorite have altered to muscovite and biotite—chiefly the latter—with an accompanying separation of silica;† *the result being the production, from a completely fragmental rock, by metasomatic changes only, of a rock which presents every appearance of complete original crystallization, and which would be ordinarily classed as a genuine crystalline schist.*

* Bulletin U. S. Geol. Survey, No. 8.

† Lehmann in his work on the "Entstehung der altkrystallinischen Schiefergesteine," demonstrates the formation of abundant secondary biotite and other minerals as accompanying metamorphoses by folding. His work does not state, however, exactly how the biotite developed.

It is important here to recall the chemical changes which occur in the alteration of orthoclase and oligoclase to chlorite, muscovite and biotite. The average content of silica of the following minerals is taken from Dana's System of Mineralogy: orthoclase, 65 per cent; oligoclase, 62 per cent; muscovite, 45 per cent; biotite, 40 per cent; chlorite, 25 to 30 per cent. Evidently where the alterations of orthoclase and oligoclase to muscovite, biotite, and chlorite have taken place so extensively as in the rocks under discussion, it is not difficult to explain the presence of the silica which has enlarged the fragments of quartz, replaced those of feldspar, and separated as independent interstitial quartz. One of these alterations is stated by Tschermak * to occur as follows: "Wenn man die dreifache Formel des Feldspathes $3(K_2O.Al_2O_3.6SiO_2)$ mit jener des daraus entstandenen Glimmers $K_2O.Al_2O_3.2SiO_2 + 2(H_2O.Al_2O_3.2SiO_2)$ vergleicht, so eigibt sich, dass von der ursprünglichen Menge $6SiO_2$ nur $2SiO_2$ in die neue Verbindung übergehen und $4SiO_2$ übrig bleiben." In farther speaking of the alteration of orthoclase to muscovite, Tschermak also observes: "Der neu enstandene Muscovit ist öfters auch von Biotit (Magnesiaglimmer) begleitet."

For the iron of the biotite in the rocks under consideration, it is not difficult to account. Pyrite, marcasite and ferrite are quite widely present in these rocks as accessory constituents. Often the relations of the pyrite or marcasite and biotite (folia of the latter surrounding particles of the former) is such as to lead to the supposition that the former minerals have furnished the iron necessary for the transformation from feldspar to biotite. At all events they indicate a quite sufficient supply of iron.

For a part at least of the magnesium of the biotite, it seems that we must look to some source extraneous to the feldspar fragments; i. e., we must regard it as having been supplied by percolating waters. That calcium-bearing and magnesium-bearing waters have been present in these rocks is evident from the occasional presence of secondary calcite and dolomite. The case is the same as that presented by the replacement of feldspar by chlorite, which has commonly taken place in the greywackes of this and other regions in the Lake Superior country. Analyses of three of the biotite-schists gave an average content of MgO of 2·22 per cent, which if entirely contained in the biotite would correspond to a probable proportion of that mineral of from 10 to 20 per cent.

The change from fragmental quartz-feldspar rocks to quartzites and greywackes in this belt having been produced by metasomatic changes, as indicated above, there is a strong presumption that the mica-schists and slates are of the same origin;

* Lehrbuch der Mineralogie, Zweite Auflage, page 462.

a presumption which is rendered stronger by the fact that in passing from east to west along the belt the biotite first appears in minute quantities, becomes gradually more plentiful until it equals in quantity the chlorite and farther west grows still more abundant, until, at English Lake, little or no chlorite is found and we have a typical mica-schist.

In the detailed descriptions below given of these micaceous rocks, I begin with one not greatly different from its original condition, and proceed toward those which are more and more completely crystalline. There is a considerable interval as to degree of alteration between each description and the succeeding one, but the gaps cannot be made shorter without unduly extending this paper. In a study of all the sections of the group, some sixty in number, these intervals are closed.

(1.) *Muscovitic and Biotitic Greywacke.*—Macroscopically this rock is gray-colored, medium-grained, and massive. It breaks with a conchoidal fracture. Under the microscope large fragments of quartz and feldspar, with the alteration-products and replacement products of the latter, compose the rock. The grains of quartz are enlarged and consequently minutely angular, although still retaining their general roundish forms. Much of the feldspar is quite fresh, many individuals showing no alteration further than a slight kaolinization. Other feldspar fragments, however, include each many grains of quartz, or a single large, reticulating quartz individual and numerous flakes of muscovite and biotite. Here the quartz, muscovite and biotite are plainly replacements and alteration-products of the feldspar. In some cases this alteration has proceeded so far as to leave but irregular, partly replaced and altered cores of feldspar which are entirely surrounded with the secondary quartz, muscovite and biotite. Again, in other places, the original rounded outlines of the feldspars are distinct, the replacements and alterations having occurred in spots through the grains. The finer-grained parts of the rock are composed of quartz, a portion of which is clastic; of feldspar—the proportion being smaller than in the coarser parts; and of biotite and muscovite. The mica is here clearly also, to a very large extent, secondary to feldspar, while there is little doubt that the small remaining fraction of the mica is of the same origin. Scattered through the finer portions of the section are numerous small particles of a black substance which is taken to be partly altered pyrite or marcasite, and perhaps also partly carbonaceous material.

(2.) *Biotitic Greywacke.*—Macroscopically this rock differs from (1) only in being of a darker gray color; and under the microscope also it is much the same except that the micaceous alteration of the feldspars has been carried farther. Well rounded fragments of quartz and feldspar with the secondary

products of the latter compose most of the section. A few of the grains of quartz are finely complex, and nearly all of them are enlarged by renewed growths. The alteration of feldspar to biotite is nicely shown. The freshest of the feldspar grains are surrounded by and more or less deeply penetrated by secondary biotite. These grains yet retain their well-rounded forms. However, in many cases, the original outlines of the grains of feldspar are lost. Often the entire surfaces of the feldspars include very numerous particles of the biotite, there remaining through such areas, here and there, little spots of feldspar which act as a unit in each area. With a low power such areas appear to be roundish aggregates of biotite. It is only with a higher power that the remaining feldspar and its true relations to the biotite are discovered. The rather sparse matrix of the rock does not differ materially from the matrix of (1).

(3.) *Biotite-schist.*—Macroscopically this rock is mottled dark-gray and black, fine-grained, and quite massive, showing roundish cleavage-areas. Under the microscope the cleavage-areas seen macroscopically are found to be well-rounded, partly-altered feldspars. These feldspars are set in a ground-mass which consists of intimately mingled grains of quartz and small brown folia of biotite with a considerable quantity of ferrite. The partial decomposition of the feldspar has resulted in the formation of very numerous small folia of biotite and a few larger ones of muscovite. In places also the feldspar is replaced by quartz. In each of the feldspar areas the secondary mica is found most plentifully at or near the exteriors of the grains, although in almost every case the alteration has proceeded to a greater or less degree quite to the center. In the matrix of the rock it is quite impossible to determine what part, if any, of the quartz is fragmental. The biotite of the matrix is in part plainly secondary to feldspar and is precisely like that found in the larger feldspars. The folia are deep brown and very strongly dichroic, and therefore probably bear a large percentage of iron. The feldspar plainly shows this rock to have been fragmental, and the alteration of feldspar to both biotite and muscovite upon a large scale is most beautifully shown. The large quantity of dark brown and black ferrite has doubtless furnished the iron required for the formation of the biotite. The peculiar spotted appearance of the section, viewed without the microscope, gives a clear idea, when taken in connection with its appearance under the microscope, of the processes by which the rock reached its present condition.

(4.) *Muscovitic Biotite-Schist.*—Macroscopically this rock is very fine-grained, grayish and quartzose, with very fine mica flakes visible. Under the microscope the thin section shows a [illegible]d ground-mass of quartz and feldspar in which are

abundant muscovite and biotite. Many of the large quartz grains include numerous folia of mica. The feldspar areas include quartz and both muscovite and biotite. This section, by itself, if not examined closely would be taken to be of a completely crystalline mica-schist in which the interlocking and mutual inclusions of the different minerals are of the most intricate kind. But, like the other mica-schists of the Penokee series, it is an ordinary clastic rock in which the metasomatic changes have gone very far. The large areas of quartz, including folia of mica, are in the places of feldspar fragments. As the feldspar has altered to mica the excess of silica has separated as quartz. Frequently the alteration of a single feldspar has resulted in the formation of a single ramifying individual of quartz, with several or many included folia of mica, mingled with which are detached remnants of the feldspar. In other cases the decomposition of a feldspar has resulted in the formation of many grains of quartz as well as numerous folia of mica. In yet other cases the feldspar areas have not altered to such extent as described above. In almost every case the rounded exteriors of the clastic grains are lost, but irregular areas of considerable size often remain considerable, which include but few folia of biotite or little replacing quartz, or both.

(5.) *Muscovitic Biotite-Schist.*—Macroscopically this rock is fine-grained to aphanitic, and dark grayish black, with rather distinct lamination. Under the microscope the sections show a rather fine-grained, apparently completely crystalline, typical mica schist. The ground-mass consists chiefly of quartz, mingled with which is feldspar, both orthoclase and plagioclase. Biotite in rather small, well-defined folia of quite uniform size is very plentiful. Muscovite is much less abundant. That all the mica is a secondary product cannot be proved from the sections from this locality taken by themselves. A portion of it is, however, certainly of this nature. Many grains of feldspar are partly surrounded and cut by folia of mica, while many of the larger particles of feldspar contain throughout their areas numerous folia of mica which in magnitude and appearance are exactly like the mass of the biotite in the rock. Quite numerous black grains and crystals of a mineral which is taken to be pyrite are seen, which are included alike in the quartz, feldspar and mica.

The rocks above described thus furnish us with a graded series, from the slightly altered greywackes to the crystalline mica-schists. There are many similar mica-schists in other parts of the Lake Superior region which there is good reason to think have had a similar origin; but those wide-spread mica-schists associated with the older gneisses are not now referred to.

The micaceous alteration of feldspars has also been very important in the production of various black mica-slates of the Penokee series. Macroscopically these slates are all exceedingly fine-grained and finely laminated, cleaving readily along the planes of lamination. In color they vary from dark gray to black. A lens shows many of them to contain numerous small particles of pyrite. Very numerous roundish black areas are contained in the fine-grained, gray material in many of the specimens. These areas in some cases show distinct cleavage surfaces and are taken to be large fragmental particles. In other cases they are dull and break without giving cleavage surfaces, while in yet other specimens these darker spots are not found at all.

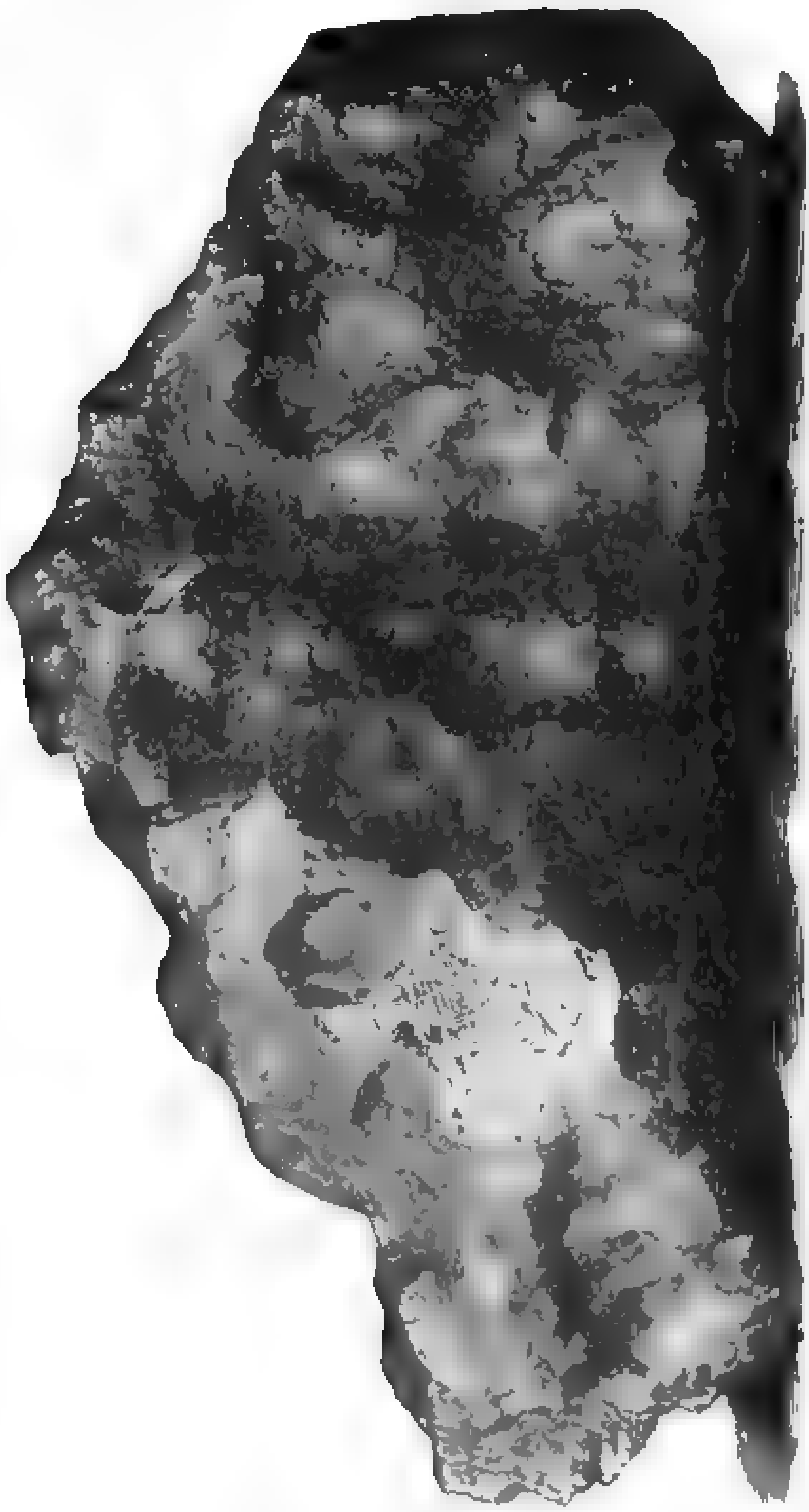
Under the microscope the rocks which have the mottled appearance described above consist of two parts, a finely crystalline matrix, and coarse, well rounded fragmental feldspars, which are always altered to a greater or less extent. This alteration is to biotite and quartz, many small folia of biotite and grains of quartz always being found in a single feldspar individual. Every gradation of this change is seen, from grains of feldspar which contain but little biotite and quartz to those in which the remaining feldspar is just sufficient in quantity to enable one to perceive that the detached particles are parts of a common individual. Doubtless also the alteration to biotite and quartz has often been carried out completely. Accompanying the biotite thus secondary to the feldspar, is much black, opaque, partly-altered pyrite in minute particles. The black, roundish spots seen macroscopically are evidently the partly-altered feldspar fragments. The degree of this alteration as determined by microscopic study corresponds exactly with the appearance of the rock as seen in the various hand-specimens. In the specimens in which the feldspar areas are well outlined and show clearly marked cleavage surfaces, the biotitic and quartzose alteration has taken place to but a small extent. In the specimens in which the feldspars are obscurely outlined and which lack cleavage the alteration has extended very far. The matrices of these rocks and the sections of those not containing large grains of feldspar are composed of intimately mingled quartz, feldspar, biotite and pyrite, with perhaps a little organic matter.* A portion of the quartz is certainly fragmental, as is evidenced by a secondary enlargement. The biotite is all believed to be due to the alteration of feldspar, much of it certainly being of this nature. The matrices of the different sections vary in coarseness and in the relative proportions of the various mineral constituents, but are alike in all essential points.

* Geol. Wis., vol. iii, p. 136.

ART. XLIV.—*On two masses of Meteoric Iron, of unusual interest;* by WM. EARL HIDDEN.

IN late years the discovery of masses of meteoric iron has been of frequent occurrence, and it has become almost un-

1.



The Independence County, Arkansas, Meteoric Iron.
Weight ninety-four pounds.
(ONE-THIRD NATURAL SIZE.)

necessary to give figures of them, unless of rare form or of unusual composition, because of their great similarity. The masses here described were not seen to fall, but were discovered

in the surface soil, and thus their history is incomplete. These two meteoric irons are, however, unusual in several of their characteristics and the writer has concluded to describe them and give them careful illustration.

Both of these masses came into the writer's possession at nearly the same time and from the same indirect source, and he hence describes them together. They were both on exhibition at the World's Industrial and Cotton Centennial Exposition in New Orleans, where they first came under his personal notice, and later into his possession. They were received in Newark, N. J., last June, at the close of the Exposition, since which time several notices of them have appeared in the local press and in other publications.

The larger mass, the one from Arkansas, will be noticed first. Figure 1 gives a fair idea of its exterior appearance.

1. The Independence County, Arkansas, Meteorite.

The following extracts from a letter from Mr. John Hindman of Elmo, Ark., dated July 2nd, 1885, sets forth the manner and time of its discovery.

"This meteor was found about the last of June, 1884, by my stepson George W. Price, on a mountain known as the 'Joe Wright Mt.,' a small eminence situated about seven miles east of Batesville (Independence County, Arkansas). The soil there was cut into deep gullies, which, farther down the mountain side converged into one. It was where these gullies met that the meteor was found. The town of Sulphur Rock is about three miles distant, southwest, from the place of the discovery."

The weight of the mass is ninety-four pounds. It is seventeen inches long and eight inches thick in its greatest diameter. Its surface is pitted with ovoid depressions of various sizes, which lie with their longer axes in nearly the same general direction. The exterior was almost black in color and looked blistered. No rusty appearance or alteration from oxidation was noticed on any part, which would go far to prove that this mass had not long been on the earth. Its size is unusual, yet several masses described within the past two years exceed it in this respect. Its most interesting feature is the presence of a hole through it, near the edge, measuring five-eighths of an inch in diameter at its smallest part. The situation of this hole is shown in the engraving (fig. 1) by the tie of a ribbon that passes through it. The length of the hole is one and three-quarter inches, and it is cone-shaped from both sides.

This remarkable feature is almost without a parallel among meteorites. It reminds us of that great ring of meteoric iron,*

* See this Journal, II, vol. xiii, p. 289, and vol. xix, p. 161.

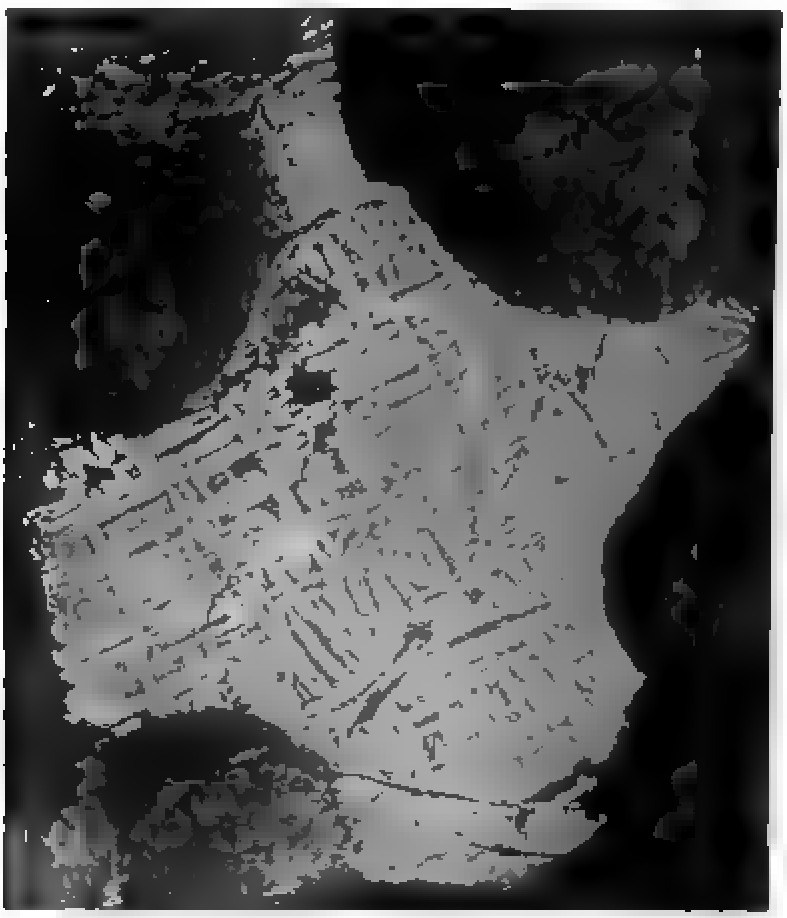
the "SIGNET" FROM ARIZONA, which weighs more than half a ton, the aperture being large enough for a man to crawl through. The presence of holes in masses of meteoric iron is difficult to explain. They may be caused by internal explosions, which, rending the sides asunder, leave, sometimes a bridge, or else a ring of metal, the explosions, resulting from the heat suddenly generated by the friction of the mass, in contact with the earth's atmosphere while the mass is moving at planetary speed.

An analysis, by Mr. James B. Mackintosh, of a piece cut from the edge, gave the following results:

Iron	91·22
Phosphorus	0·16
Nickel and cobalt	8·62 by difference.
	100·00

(Other elements not looked for.)

2.



Widmanstatten lines (natural size) on the Independence County, Arkansas, Meteoric Iron.

It belongs to the class "Holosiderite" of Brezina—being free of stony matter, and closely resembles the irons of Chulafinnee,* Alabama, and Whitfield County,† Georgia, previously described by the writer.

* This Journal, III, vol. xix, p. 370. † Ibid, vol. xxi, p. 286.

The small surface which in fig. 1 shows faintly and in reduced size the internal crystalline structure, is better shown in fig. 2; which is a reproduction of exact natural size, by the Ives process of photo-engraving.

The Widmanstätten lines in this iron are remarkably perfect, unusually so for so large a mass.

Troilite (FeS), having a bronze color and luster occurs as thin seams and veins on the polished face and extends far into the mass. Schreibersite, as rather large bright points, was also identified.

This is the second meteoric mass found in Arkansas, up to this date; the other being from Newton County,* where it was found in 1860. The latter differs from the Independence County mass in consisting of much olivine, bronzite and other stony matter.

2. The cuboidal mass of Meteoric Iron, from Laurens County, South Carolina.

This undescribed mass of meteoric iron was found in 1857 in the northwestern corner of Laurens County, South Carolina,

3.

Meteoric Iron (cuboidal), from Laurens Co., S. C. (natural size.)

and was deposited, soon after its discovery, in the cabinet of the Laurensville Female College, at Laurens Court House, S. C.

* This Journal, II, vol. xl, p. 213.

It remained there until it was sent to the Exposition at New Orleans in 1884 as a part of the South Carolina exhibit. The writer is indebted to R. W. Milner, President of the Laurensville Female College, for the above information, and also for the possession of the meteorite.

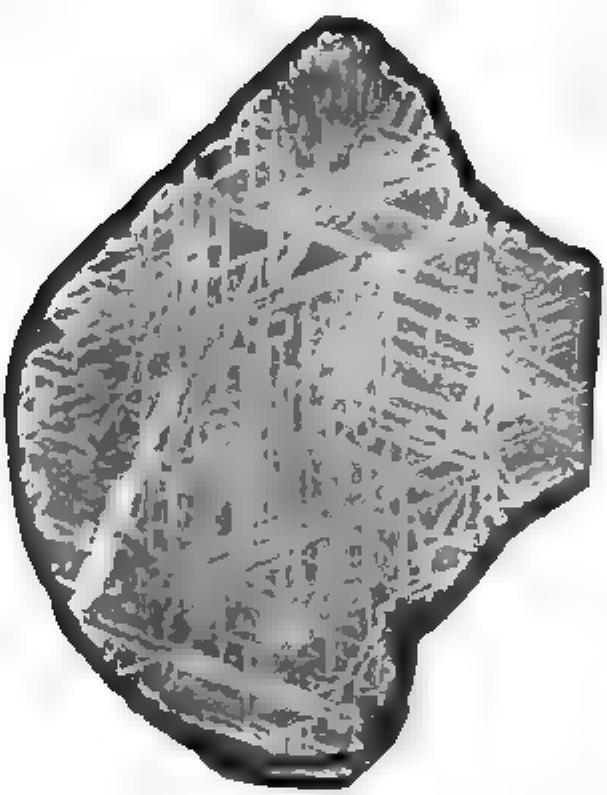
Its weight is four pounds and eleven ounces. Its shape is shown in fig. 3 which is of natural size.

The perfection of the Widmannstätten lines, as shown in the smoothed surface* of fig. 3, is unusual. Their fineness marks the mass as belonging to a class of rare meteorites.

The writer's attention was directed, at first, to the apparent *cuboidal* aspect of this mass, and with that idea, he had the panel smoothed out, as in fig. 3, merely to prove by the internal structure, whether or not this shape was accidental.

The relation of the etched lines to the profile gives evidence that in part, at least, the outward shape is due to a uniform crystallization of the mass. The perpendicular lines are nearly parallel to the two sides (this is better proved while examining the mass, in hand), and agree fairly enough with the top and bottom sides to be consistent with a cube. The back of the mass is bluntly pointed (cone shape) toward the left upper side and covered with large depressions.

4.



Wishing to further test the homogeneity of the mass, it was cut through at the base of the cone-shaped projection on the back and the surface shown in fig. 4 developed. Here the internal structure is exhibited even more beautifully than in fig. 3, and the angles are those which octahedral crystallization would present on a cubic face.

All over the mass a thin formation of limonite was observed, this coating being much thicker over the cuboidal faces than on the rough surfaces at the back. The thickness of this crust is well shown by fig. 4

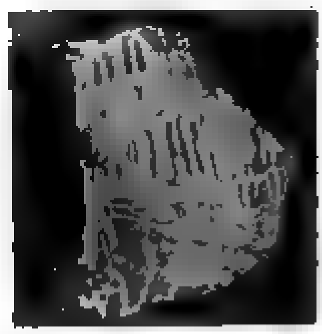
The dark rhomboidal spot near the middle of fig. 4 was found to consist of solid ferrous-chloride (Lawrencite). Several

* This surface was drilled out with a lathe, then smoothed, polished and etched with diluted nitric acid.

similar spots of this same rare species were noticed on the face shown in fig. 4. Their deliquescence first attracted attention to them. The presence of hydrogen (occluded) was proved by simply rubbing the smoothed surfaces with powdered sulphur, when instantly, the disagreeable odor of hydrogen sulphide was made noticeable. In the action of nitric acid on the smoothed surfaces the presence of carbon was also proved conclusively.

A few words as to what seems to be the point of impact when this mass fell. By referring back to fig. 3 and noticing the lower right hand edge a nearly straight surface of two centimeters length is seen, and as this was a natural flat surface I smoothed and etched it, with the result as shown in fig. 5. A set of lines, of structure at about 90° angle, is at once noticeable, as well as an increased fineness of detail as compared to the other figures. That this face is the place of impact the writer has no doubt after comparing its surface with the other figures.

5.



Laurens Co. iron.

A careful analysis by Mr. James B. Mackintosh yielded:

Iron	85·33
Nickel	13·34
Cobalt	0·87
Phosphorus	0·16
	99·70

Sulphur, trace. Carbon, undetermined.

These results place this mass among the few that are exceedingly rich in nickel and cobalt. It approaches in this regard the meteorites of Babb's Mill* (Green Co., Tennessee), Ni 14·73 per cent [mean of three analyses], and that of Kokomo† (Howard Co., Indiana), Ni 12 29 per cent. Its cobalt percentage is probably above that of any other on record, being nearly 1 per cent.

The Widmannstätten figures resemble in their perfection and abundance, those shown on the Smith Mountain‡ (Rockingham Co., N. C.) iron described by Smith. This is the fourth meteoric mass found in South Carolina; the others being known under the names of the Bishopville§ (stone); Chesterville;‖ and Lexington County ¶ (Ruff's Mt.) meteorites.

I take pleasure in here expressing my thanks to Mr. Mackintosh for his kindness in furnishing the above analyses.

Newark, N. J., Dec. 21st, 1885.

* This Journal, I, vol. xlix, p. 342.
† Ibid, III, vol. v, p. 155; and vol. vii, p. 391 ‡ Ibid, III, vol. xiii, p. 213.
§ Fell March 25, 1843. ‖ This Journal, II, vol. vii, p. 449.
¶ Ibid, II, vol. x, p. 128.

ART. XLV.—*Notice of a new Genus of Lower Silurian Brachiopoda;* by S. W. FORD.

SEVERAL months since Mr. Walter R. Billings, of Ottawa, Canada, sent me a number of wax impressions of the interior of a nearly perfect specimen of the ventral valve of the species described by the late Mr. E. Billings, in 1862, under the name of *Obolella desiderata* (Palæozoic Fossils, vol. i, p. 69). These impressions interested me very much, affording, as they did, more perfect knowledge of the internal structure of this species than had previously been obtained; and I subsequently received from Mr. Billings for study, the specimen itself, which belongs to his private collection, accompanied by the statement that, in case I might so desire, I was at liberty to publish a notice of it. This I some time since resolved to do; but various obstacles have prevented, until now, the fulfillment of my intention.

A careful study of Mr. Billings's specimen, and an examination of the original material used by the late Mr. E. Billings in his description of the species, kindly granted me by Mr. J. F. Whiteaves, have convinced me that *O. desiderata* may be taken as the type of a new genus, which will probably include several described Lower Silurian species. It differs from *Obolella* in

Genus BILLINGSIA, n. g.

1. 2.

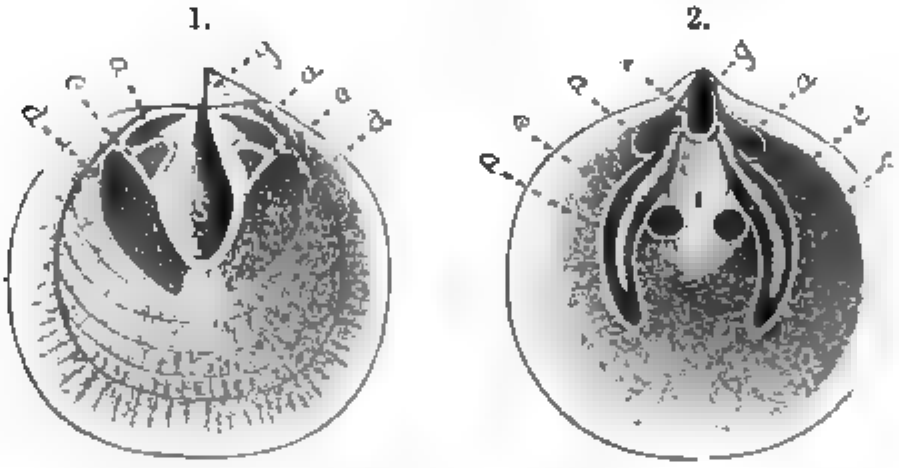


Fig. 1.—Interior of a nearly perfect specimen of the ventral valve of *Billingsia desiderata*, enlarged four diameters. *aa*, cardinal, *cc*, central and *dd* lateral muscular scars; *g*, the groove in the area; *s*, the spoon-shaped cavity beneath the beak or rostrum.

Fig. 2.—Interior of the ventral valve of *Obolella crassa* Hall sp., enlarged about 2½ diameters. *aa*, cardinal, *cc*, central and *dd* lateral muscular impressions. *g*, the groove in the area; *t*, pit into which the groove terminates.

the form and arrangement of its muscular impressions, in the possession of a thinner shell, and in other particulars. For this species I therefore propose a new generic name, BILLINGSIA, in honor of Mr. E. Billings, the late eminent Paleontologist of the Canadian Geological Survey.

Generic characters.—Shell thin, calcareous, inarticulate, longitudinally ovate or sub-circular, convex. Ventral valve with a solid beak and a minute area, which, in the typical species, is grooved for the passage of the pedicle as in *Obolelia.* Muscular impressions in the ventral valve six, one pair situated close to the cardinal edge, one on either side of the median line; a second, smaller pair, placed directly below the former; and outside of the latter a third pair of large elongate or subreniform impressions, converging forward. Beneath the rostrum there is a prominent spoon-shaped pit or chamber separating the above mentioned impressions, with which the groove of the area is confluent. In the dorsal valve there are also three pairs of impressions disposed in nearly the same manner with those of the ventral valve. The dorsal valve is not known to possess an area. The surface is concentrically striated.

If we compare the interior of the ventral valve of *Billingsia desiderata* with that of *Obolella crassa* (see figs. 1 and 2) we shall find that they present several important differences. They coincide in this, that they each possess three pairs of muscular impressions; but the central pair in *B. desiderata* sustain a different relation to the cardinals than those of *O. crassa*, while the size, form and disposition of the laterals are plainly distinctive. Moreover, the large spoon-shaped cavity beneath the rostrum has not, so far as I am aware, any exact homologue in any known species of *Obolella.* Its large size and forward extension forbid our interpreting it as the homologue of the pedicle pit of *Obolella*, although the pedicle very probably terminated in it.

Obolella? ambigua Walcott (Paleontology of the Eureka District, p. 67, pl. 1, figs. 2 *a*, *b*, *c*, 1884) has also a thin shell, with muscular impressions similar to those of *B. desiderata*, and will probably fall into the same genus. *Obolella pretiosa* Billings and *O. Ida* Billings (Palæozoic Foss., vol. i, pp. 68 and 71) are also thin-shelled species; and, when their internal structure shall have been determined, will very possibly prove to be generically identical with *B. desiderata.* All of these species occur low down in the Silurian rocks, and apparently at about the same geological horizon; *B. desiderata* and *O. Ida* having been described from the Lévis formation of the Canadian geologists, *O. pretiosa* from the Sillery, and *O.? ambigua* from the lower portion of the "Pogonip group" of Central Nevada.

It is possible that *Billingsia* should be regarded as only a sub-genus of *Obolella.* My present impression however, is, that it probably sustains about the same relation to that genus, that the genus *Olenellus* does to *Paradoxides.*

Schodack Landing, N. Y., March 2d, 1886.

SCIENTIFIC INTELLIGENCE.

I. Physics and Chemistry.

1. *On the Law of Gaseous Flow.*—Hirn has published an extended memoir on the law of flow of elastic fluids, in which he has given the results of experiments made to determine whether a gas under a constant pressure flows into a reservoir where the pressure, also constant, is less than its own, with a velocity indefinitely increasing as the pressure in the reservoir decreases; or whether there exists a limiting velocity which is attained when this second pressure is zero. Theoretically two kinds of equations have been employed to express the law of flow. In one of these, the work of expansion is neglected; in the other, more recent, it is included. Comparing together the volume-equations of the two kinds, it appears that they both give a maximum value for the volume of gas flowing under constant pressure into a reservoir where the counter-pressure is variable. As to the velocity-equations, the former indicates a continual increase in velocity from zero to infinity with decreasing pressures in the reservoir; while the latter, or Weisbach's equation, on the contrary, gives velocities converging toward an upper limit, attained when the gas passes into an absolute vacuum. Experiment then is to be invoked to decide, 1st, whether there is such a maximum value for the volume of gas thus flowing, and 2d, whether the velocity of the flow tends toward a limiting value as the counter-pressure diminishes. The apparatus consisted of a weighted gasometer of known capacity, which forced air through a suitable orifice into a reservoir kept exhausted by a water-pump. Five forms of orifice were employed, two of which were simply conical openings in a thin plate of brass 3^{mm} thick, and the others conical ajutages, whose side formed angles of 13° and 9° respectively with the axis, one of the two latter terminating in a cylindrical glass tube. The pressure in the gasometer was maintained constant by the weights upon it, and the flow was measured by noting electrically its rate of fall. The varying pressure in the reservoir was also recorded electrically. Representing graphically the results of the experiments, it appears that the maximum value to which the volume-equations point has no existence; and that with regard to the velocity of flow, the limiting value indicated by the equation of Weisbach, has equally no foundation in fact. Hence the author concludes that the true law of gaseous flow produced by difference of pressure, is still unknown; and concludes by calling attention to the discrepancy between these results and those predicted by the kinetic theory of gases. According to this theory, dry air under a constant pressure would flow into a perfect vacuum with a velocity which cannot exceed that of the gaseous molecules themselves at that temperature, which is about 485 meters per second. But in the experiments above mentioned, even under a notable

counter-pressure, velocities of 6000 meters per second were observed; necessitating it would seem, a revision of the theory.—*Ann. Chim. Phys.*, VI, vii, 289–349, March, 1886. G. F. B.

2. *On the Existence of Nitryl Chloride.*—WILLIAMS has examined experimentally the common statement of the text-books that nitryl chloride not only exists but is readily prepared; making use of such reactions as seemed likely to afford this compound. In the first, phosphorus oxychloride was allowed to drop from a tap funnel upon pure dry lead nitrate contained in a flask connected with a condenser. But only a few drops of a yellowish red liquid were obtained; the gas which escaped continually, having the properties of chlorine, while reddish vapors appeared in the flask. Then in the same apparatus, pure nitric acid was allowed to drop on the phosphorus oxychloride contained in the flask. More distillate was now obtained but the oxychloride was also always present. On treating nitric acid and phosphorus oxychloride in equivalent proportions in sealed tubes for two hours at 100°, two layers appeared, the upper deep red and mobile, the lower yellow and viscid, most probably phosphoric acid. On opening the tubes, chlorine and hydrochloric acid gases escaped. Dry fused potassium nitrate was then placed in a test tube and sulphuric chlorhydrin was poured upon it. Heat was evolved and chlorine and nitrogen tetroxide were given off in large quantity. On passing the vapors through a condenser cooled to —18°, a small quantity of a deep red liquid was obtained which proved to be a solution of chlorine in nitrogen tetroxide. Sulphuryl dichloride was then sealed up with an equivalent quantity of potassium nitrate and heated to 100° for several hours. A certain amount of red gas was formed and on opening the tube chlorine was collected over hot water. Hence the author infers that in general whenever a nitrate is acted upon by an acid chloride, nitryl chloride is not obtained as such but only its constituents, nitrogen tetroxide and chlorine. Three series of experiments were made to form nitryl chloride by direct synthesis. In the first, the chlorine and nitrogen peroxide were passed through a red hot tube, as Hasenbach suggested. But since the tetroxide decomposes at a red heat into the dioxide and oxygen, it was probable that the product would be nitrosyl chloride; and this was found to be the fact, as was proved by analysis. In the second and third the mixture was passed through a large U tube, filled with broken glass and heated to 130°–150°. The product was a red volatile liquid, whose observed vapor density agreed best with that calculated on the hypothesis that all the chlorine was free. In the third series, however, the distillation was continued for a short time only and the accordance was closer. The author concludes therefore, that nitryl chloride cannot be formed by direct synthesis; the product, like that obtained by the other methods, being merely a solution of chlorine in nitrogen peroxide.—*J. Chem. Soc.*, xlix, 222–233, April, 1886. G. F. B.

3. *On a new Oxide of Zirconium, and on its use in the Determination of this element.*—While making an analysis of the mineral koppite, BAILEY found that a precipitate containing ferric oxide yielded a notable quantity of zirconia on treatment with tartaric acid and ammonium sulphide. On redissolving it and adding hydrogen peroxide to the solution, a white bulky precipitate was obtained which after washing, gave with hydrochloric acid and potassium iodide, on heating, free iodine; proving the presence of a peroxide. This reaction, Clève had observed about the same time, and had assigned to the new oxide the formula ZrO_3. To investigate this substance, Bailey prepared zirconium-potassium fluoride by Wöhler's method, converting this salt into the sulphate, and precipitated the solution directly with hydrogen peroxide. A portion of the moist peroxide was distilled with hydrochloric acid in a small flask, the distillate being passed into a solution of potassium iodide, and the iodine set free being determined by Bunsen's method. In the residue in the flask the zirconia was determined directly. The result gave Zr 69·564, O 30·436. Since the moist precipitate after standing three months gave Zr 69·284, O 30·716, the author infers that the new oxide is perfectly definite and stable. From these figures, the formula of the new oxide is Zr_2O_5. Freshly precipitated it is less readily soluble in dilute sulphuric acid than zirconia and hence the two may thus be separated in the cold. The author calls attention to this reaction as a convenient means of separating zirconium from the elements likely to be associated with it. Iron and alumina, as Clève has shown, are not precipitated by hydrogen peroxide, nor is titanium, niobium, tantalum, tin, or silicon. A very dilute solution does not effect the precipitation but with a moderately concentrated one the precipitation is complete. When of such a strength as to yield 120 vols. of oxygen on heating, hydrogen peroxide precipitates Zr_2O_5 at once and completely from its solution in sulphuric acid. Even if it yields only 20 vols. of oxygen, the solution effects a complete precipitation on standing for a short time.—*J. Chem. Soc.*, xlix, 149–152, March, 1886. G. F. B.

4. *On the determination of Vanadium by means of Oxycellulose.*—In studying the properties of oxycellulose, produced from cellulose by oxidation, WITZ observed, some time ago, the decided property which it possessed of fixing basic coloring matters, especially metallic oxides. In connection with OSMOND, he now suggests the use of this property in chemical analysis, since, other things being equal, the proportion of a base fixed on a given weight of oxycellulose is a function of the quantity contained in the bath. So that if the base is itself colored, or if it may produce color by the action of a convenient reagent, a very delicate reaction may thus be developed. In the present paper he considers its application to vanadium salts, using for this purpose the well known reaction with potassium chlorate for the preparation of aniline black. The method requires five operations: (1) preparation of the strips of calico partially

transformed into oxycellulose, by paste printing. (2) immersion in the vanadium bath for a definite time, rinsing and drying at 40°, (3) printing the strips sewed end to end, with bands of the usual mixture of aniline black less the vanadium, (4) developing the black in the oxidation chamber, and (5) classification. In testing the process, hypovanadic chloride was prepared from the metavanadate of ammonium by the action of hydrochloric acid, the reduction being effected by means of glycerin, the excess of acid being removed by evaporation, and the solution diluted. Six baths were thus prepared, containing progressively decreasing quantities of vanadium from one tenth to one millionth of a milligram per liter. The duration of the immersion was 8 hours at 15°. The specimens were prepared by Osmond at Creusot and classified by Witz at Rouen. The order of classification was exactly that of the dilution, the strip treated in the sixth bath which contained only one millionth of a milligram of vanadium per liter being sharply distinguishable from that treated with pure water. The authors give the effects produced by the presence of foreign salts upon the result, and say that by this test they have been able to detect the presence of vanadium in the water supplied to Creusot and in the mineral water of Saint Honoré-les-Bains; but not in the body of a sheep of the region.—*Bull. Soc. Chim.*, II, xliv, 309–315, March, 1886. G. F. B.

5. *On the Physical Properties of the C_nH_{2n+2} series of Hydrocarbons from American Petroleum.*—BARTOLI and STRACCIATI have examined the physical properties of twelve hydrocarbons of the marsh gas series prepared by careful fractioning, from Pennsylvania petroleum. They find that as the molecular weight increases, (1) the expansion-coefficients, both between 0° and 30° and between 0° and the temperature of ebullition, decrease regularly; (2) the molecular volumes at the boiling point are not the same as those which are calculated by Kopp's formula; an increase of CH_2 not always corresponding to the same increase of molecular volume, the differences being superior to errors of observation; (3) the capillary constants a^2 and α, measured at the ordinary temperature, increase continuously, thus disagreeing with Wilhelmy's result; (4) the coefficients of friction at the temperature of 22° to 23° increase rapidly and with regularity; (5) the index of refraction measured for the line D, increases regularly; (6) these hydrocarbons have nearly the same specific heat; (7) they do not conduct the electric current; and (8) they have specific inductive capacities which follow Maxwell's law. The precise values are given in a table.—*Ann. Chim. Phys.*, VI, vii, 375–383, March, 1886. G. F. B.

6. *On the Synthesis of Conine.*—LADENBURG has studied the reaction of paraldehyde upon α-picoline, with a view to the synthesis of conine. The reaction requires a high temperature, the yield even at 250° being small. The product was an oily liquid difficultly soluble in water, having a boiling point at 190°–195° and having an odor like conyrine. Analysis gave numbers

near those of an allylpiperidine. This oil readily underwent reduction and gave almost the theoretical quantity of a base the hydrochlorate of which was a white crystalline permanent salt. The cadmium-double iodide was prepared, and like that of conine, was an oily liquid solidifying on contact with a crystal-fragment. On re-crystallization it gave well formed crystals exactly resembling the conine salt, fusing at 117°–118°, and affording coincident numbers on analysis. From the mother liquors a base was obtained which had the odor and solubility of conine, and which boiled at 166°–170°. The hydrochlorate made from this formed brilliant needles fusing at 203°. The author believes therefore that the new base is probably identical with conine.—*Ber. Berl. Chem. Ges.*, xix, 439–441, March, 1886. G. F. B.

7. *On the Chemical Action of Bacterium aceti.*—BROWN has studied the chemical action of pure cultivations of *Bacterium aceti* upon various organic substances. The ferment used was originally taken from the surface of a beer which had been exposed to the air in a warm place till acetic fermentation had set in. It was inoculated into the first of a series of 10 test tubes, containing a sterilized solution of 2 per cent ethyl alcohol in yeast water; an inoculation being made to the next tube as soon as a visible growth was observed. Ethyl and propyl alcohols were readily converted into acetic and propionic acids respectively. Dextrose in a 2 per cent solution, yielded gluconic acid. Sucrose in a 4 per cent solution, underwent no change. Mannitol was completely oxidized by *B. aceti* and yielded mainly levulose. By sodium amalgam, this levulose as well as that from inulin and invert sugar may be re-converted into mannitol.—*J. Chem. Soc.*, xlix, 172–187, March, 1886. G. F. B.

II. GEOLOGY AND MINERALOGY.

1. *Note on the occurrence of* OLENELLUS (?) KJERULFI *in America*; by F. G. MATTHEW.—A good deal of interest attaches to the occurrence of this species in America, as its position in Europe is beneath that of the beds carrying Paradoxides, while in America the genus Olenellus is supposed to belong to the Middle Cambrian—the horizon corresponding to the Olenus-bearing measures of Europe.

In New Brunswick this species has not been found in the St. John Basin of Cambrian rocks, but it occurs in that of the Kennebecasis river, where it is associated with a number of species found in the St. John Basin in the bands *c* and *d* of Division I. The species are similar and in some cases identical with those of the Menevian Groups of Wales. The band *c* of the Saint John Basin which corresponds more nearly to the Solva group in its fauna than to the Menevian, has been well explored, and if *O.* (?) *Kjerulfi* were common in it, it would probably have been found ere now; but it has not been met with. If this species were

present in America at a horizon corresponding to that at which it occurs in Europe it should show itself in band *b* of Division I, but so far it has not been recovered from this horizon; on the contrary the species found to be associated with it in the Kennebecasis Basin are mostly those that belong to band *d* or higher measures.

In Newfoundland *O.* (?) *Kjerulfi* occurs in association with *Agraulos strenuus*, *Hyolithes Micmae*, etc. The two species named occur in Division I, band *c* in the St. John Basin, and the second occurs also in *d*.

Olenellus (?) *Kjerulfi*, was originally described as a Paradoxides by Linnarsson, but Prof. W. C. Brögger referred it subsequently to Olenellus. It is perhaps doubtful if the species belongs there: the peculiar pygidium of Olenellus has not been recorded in connection with it, and the eyelobe is that of Paradoxides. But on the other hand the glabella is not enlarged in front as in the true Paradoxides, and all the furrows turn backward as in Olenus and other genera of the Middle Cambrian. Among true Paradoxides, *P. Acadicus* in its straight-sided glabella, its moderately arched and uniformly narrow eyelobes, and its granulated test, appears to be more closely allied to this species than any other.

St. John, N. B., April, 1886.

2. *Geological formations underlying Washington and vicinity. Report of the Health Officer of the District of Columbia, for the year ending June* 30, 1885. [By SMITH TOWNSEND, M.D., Health Officer.] Washington, 1886. (8vo, pp. 1–160, folding plates 1–16+3.)—In addition to the customary sanitary, hygienic, statistical and administrative matter, this report contains the substance of a communication from the office of the U. S. Geological Survey, embodying some preliminary results of an elaborate survey of the District of Columbia, in which the formations underlying Washington and its environs are for the first time clearly discriminated and named.

It appears that Washington is located in a triangular depression or amphitheatre, rising 20 to 80 feet above tide, bounded on the east, north, and southwest by bluffs rapidly ascending by successive terraces to altitudes of 150 to 300 feet, and traversed by the Potomac river, the Eastern Branch, and some minor streams. Within this amphitheatre and rising about its periphery (except on the east) to an altitude of about one hundred feet is a well defined Quaternary deposit to which the name *Columbia formation* is applied. Its upper portion consists of loam or brick-clay, and its lower of sand, gravel, bowlders (up to four or five feet in diameter), or all combined. Its thickness is variable, the upper member ranging from almost nothing to perhaps 20 or 30 feet, and the lower from perhaps 1 to 20 feet. The deposit is more or less distinctly stratified throughout, particularly in its lower division; and at the base it frequently becomes a simple bed of bowlders and gravel, without considerable admixture of finely comminuted materials. The entire formation appears to

represent a subaqueous delta of the Potomac river, formed when the sea rose far above its present level and fashioned the marine terraces exhibited in the bluffs. Its absence above sea level east of the Eastern Branch may be attributed to a dislocation (of which there is other evidence) trending parallel with the Appalachians and the Atlantic coast. The most extensive formation in the District is that hitherto known as "Newer Mesozoic" in Virginia, and "Iron Ore Clays" in Maryland. It is denominated the *Potomac formation.* In structure and composition it is bipartite, the upper portion consisting of highly colored banded and mottled clays, with intercalations of sand and quartzose gravel, and the lower of sand and gravel with intercalations of clay. In both divisions stratification is inconstant and often absent, and the materials are sometimes indiscriminately intermingled. The formation is practically destitute of fossils in the District, but yields abundant plant-remains in Maryland and Virginia. It appears to consist of inosculating deltas of the Potomac and other Atlantic coast rivers and the littoral deposits into which they merge, laid down along a bay-indented coast upon a highly inclined and irregular sea-bottom produced by combined depression and sea-ward tilting of a deeply corroded land surface in late Jurassic or early Cretaceous time. The Potomac formation rests everywhere on the eroded edges of highly inclined gneiss which has not yet been thoroughly studied, but which is probably an extension of that of New York and Philadelphia.

W. J. McG.

3. *Theories of Ore-deposits;* by M. E. Wadsworth. (Proc. Boston Soc. N. Hist., xxiii, 197.)—Professor Wadsworth, after referring to a tendency to change in the minerals of igneous and metamorphic rocks, and speaking of the unstable condition as a consequence of origination at high temperatures, explains the changes by appealing to "percolating waters" and "external agencies," and refers to the same causes the "segregation or localization of ores" into veins, where such veins are not directly of igneous origin. His closing paragraph (p. 203) is as follows: "The general alteration manifests itself in a universal chemical or molecular transference—a transference of material, leading to the segregation or localization of the ores in the places in which they are now found; it manifests itself in the deposition of mineral matter in the veins and cavities of the rocks themselves, in deposits from springs in bogs, lakes, etc. From this it would follow that all ore-deposits not eruptive are superficial phenomena as regards the earth and dependent on its external agencies, although they may be deep enough so far as man is concerned. Again, few of these ore-deposits would be expected except in regions in which percolating waters and their resulting metamorphism have been efficient agents; while the various forms of ore-deposits would be expected to be associated with and grade into one another."

The method urged appears to exclude any aid in the making of veins from vapors of water or other material ascending from the

depths of fusion along with the igneous rock, and also, the agency of any vaporized materials derived from the walls of the fissures through the heat, any part of which walls may, as far as is known, yield ores, and the last few miles of which may intersect rocks containing a per cent or so of moisture (0·6 per cent would be a pint to the cubic foot of rock), or holding bodies of fresh or salt water between the beds. Subterranean waters have come from above and may be included among "external agencies;" and if so, the theory is wide enough to cover a large part of vein-making, and so far falls in with views that have been advocated by others.

4. *On Slaty Cleavage and allied rock structures with special reference to the mechanical theories of their origin;* by ALFRED HARKER, M.A., F.G.S. Brit. Assoc. Rep. for 1885.—This is a thorough, partly mathematical, and judicious discussion of the subject of slaty cleavage. The general conclusion is expressed in the following statement from page 38: "The theories discussed in the foregoing pages make the cleavage of rocks a result of lateral thrust operating throughout larger or smaller tracts of country; and the extreme stages of the structure, which involve mineralogical as well as lithological changes, a consequence of the intense stresses in the earth's crust to which mountain-systems owe their structure." While admitting that the impression of the cleavage structure is of later date, in the main, than the tilting and flexures observable in them, he still regards the cleavage and folding as concomitant though not simultaneous effects of the same lateral pressure.

5. *Index der Krystallformen der Mineralien* von Dr. VICTOR GOLDSCHMIDT. Vol. I, part 1. 280 pp., large 8vo. Berlin, 1886 (Julius Springer).—The task which the author has undertaken is one of very great magnitude, namely, the presentation of a complete catalogue of the forms observed on the crystals of each mineral species, with the names of the observers, the letters employed by different authors, the literature, and so on. The part now issued, of 288 pages, is only half of the first volume, and the whole work is to consist of six such parts in three volumes. The Introduction includes the development of the special symbols employed by the author, with the forms of calculation adapted to them, and also a very thorough explanation of the mutual relations of the different systems of notation for the planes of crystals from Haüy down. The author's general symbol (except in the hexagonal system) takes the form pq, which is equivalent to the hkl of Miller reduced to a form where the l is unity, that is, in general $pq = \frac{h}{l}\frac{k}{l}$. It is shown that this form brings out clearly the relations of the planes and lends itself easily to purposes of calculation. Those who have become familiar with the system to which the name of Miller is ordinarily attached will be slow to believe that any other system can be at once so clear and convenient, and will be likely to go further and question the desirability of introducing a new system at a time when so great a

degree of uniformity has been attained among the workers in all countries. The author, however, may fairly be regarded as having won for himself the right to have his methods carefully studied, and their claims fully considered, by the admirably thorough and complete way in which he has expounded the not often understood systems now gone out of use, especially those of Mohs and Hausmann. The same exhaustive methods have been devoted to the elaboration of the catalogues of planes, as the frequent lists of corrections that are given for the statements of earlier authors show, and to the complete tables for transforming the symbols from the form belonging to the position of one author to that of another. In this matter of the orientation of the crystals of each species, the author has shown himself more arbitrary than could have been desired. Simplicity of form of the symbols is in his view the one controlling condition, to which questions of isomorphous relations ("analogies") and all other points are to be subordinated. Thus he deviates from the accepted position for aragonite, although the reasons for its acceptance are so strong, and makes the prism a macrodome, and similarly in many other cases. The work, however, is one which no thorough mineralogist should be without, even if he is not inclined to follow it in all respects.

6. *Catalogue of Meteorites.*—A new catalogue of the large collection of meteorites in the British Museum has been recently issued by Mr. L. Fletcher. The catalogue is also a guide to that department of the Museum and contains an interesting "introduction to the study of meteorites." As is well known, the collection is one of the finest of the world both as regards numbers and the size of the specimens represented; 360 distinct falls are included in the catalogue.

7. *Brief notices of some recently described minerals.*—EMMONSITE is a ferric tellurite from the neighborhood of Tombstone, Arizona, exact locality unknown. It occurs in translucent crystalline scales of a yellowish green color, imbedded in a hard brownish gangue consisting of lead carbonate, quartz and a brown substance containing the hydrated oxides of iron and tellurium. The crystallization is probably monoclinic, the specific gravity about 5. The material was scanty and not entirely pure, so that the results of the chemical analyses were somewhat doubtful. The mean percentages accepted, after deducting impurities, are: Te 58·75, Se 0·53, Fe 14·29, H_2O present, but amount uncertain. It is concluded that the mineral is a ferric tellurite, but the formula is doubtful and further examination is needed to establish its true relations. Dr. Genth states that it is distinct from his *ferrotellurite.* Named after Mr. S. F. Emmons, of the U. S. Geol. Survey, by W. F. Hillebrand.—*Proc. Col. Sc. Soc.*, ii, part I, 1885.

KAINOSITE (from *καινος*, unusual) is from Hitterö, Norway. The only specimen known is a fragment of a large six-sided prism (orthorhombic or monoclinic), showing two cleavages at an angle of nearly 90° with each other. It is translucent, of a yellow-

brown color and greasy luster. The hardness is 5·5 and the specific gravity is 3·413. The mean of two analyses of material dried at 100°, gave:

SiO_2	$Y_2O_3Er_2O_3$	Ce_2O_3	CaO	MgO	FeO	Na_2O	CO_2	H_2O
34·63	37·67	*tr.*	15·95	0·03	0·26	0·40	5·90	5·26=100·10

The composition of the mineral is so remarkable that it is to be hoped that more specimens for examination may be found. A. E. Nordenskiöld in *Geol. För. Förh., Stockholm*, viii, 143, 1886.

HYDROGIOBERTITE is a hydrous carbonate of magnesium occurring in spherical forms which are compact and of a light gray color. Imbedded in them are minute crystals of magnetite. The specific gravity is 2·149–2·174. An analysis yielded:

MgO	CO_2	H_2O
44·91	25·16	29·93 = 100

which corresponds closely with the formula $2MgO, CO_2, 3H_2O$. The mineral was found in an isolated mass of augite porphyry from the neighborhood of Pollena.—E. Scacchi in *Rend. R. Accad. Napoli*, December, 1885.

8. *The various forms in which gold occurs in nature.*—Professor W. P. BLAKE has contributed to the Report of the Director of the U. S. Mint for 1884 an article of twenty-five pages on the forms of native gold. He summarizes the observations of the various authors, giving a series of figures of the commonly occurring forms of crystals; to these he adds some original observations upon the peculiar distorted and cavernous crystals from California, which are fully illustrated. The remarks on the occurrence of gold in different localities, upon gold nuggets, and other points will also be read with interest.

III. BOTANY.

1. *Handbook of Plant Dissection;* by T. C. ARTHUR, M.Sc., CHARLES N. BARNES, M.A., and JOHN M. COULTER, Ph.D., editors of the Botanical Gazette. New York: Henry Holt & Co. 1886; pp. 256, 12mo.—These three active botanists and teachers, mostly Professors in Indiana colleges, where botany is much in advance, have conspired to furnish their students and all others who may be advantaged thereby with a succinct manual for laboratory use in elementary vegetable biology. Their work appears to be a very painstaking and faithful guide and helper to a kind of botanical work which is now popular, and for which great and various facilities—instrumental and other—have recently been supplied, by which such investigation is rendered practicable and profitable. So that now—thanks to the increase of good teachers, and of such helps as books of this sort—histology and organogeny are becoming a part even of elementary botanical education. The results are hopeful. For intending medical students, who cannot pursue botany far, and who early need this special

training, the biological laboratory offers the most needful training from the beginning. But it may be questioned whether, for common education, there is not a tendency to introduce histology too early into the course; also to treat it too technically and so to say Germanically. This tendency is most natural under the circumstances; but as our writers and teachers grow stronger in their grasp, they may be expected to discard a deal of superfluous terminology,—some wholly superfluous, more of it unnecessary for the occasion. Among these terms perhaps the most abhorrent are those (such as pollen-spores) which come from taking Cryptogamia as the norm, and imposing its terminology upon Phanerogamia. Nomenclature is one thing: homology is another. We do not usually say "stamen-leaves" and the like. The Germans of our day excel in investigation and supply excellent material. But they seem to lack the gift of exposition and the sense of proportion; and so, for educational purposes, their writings need something more than translation.

The remarks we have been led into are not specially *apropos* to the present little book, which is a really commendable one for its purpose. A. G.

2. *Japanese Botany.*—The sixth fascicle of *Diagnosis Plantarum Novarum Asiaticarum*, by Dr. Maximowicz, of St. Petersburgh, issued in February, 1886, contains several Japanese plants, communicated with drawings, and named by *Itô Tokutaro.* Among them is "Podophyllum Japonicum, *Ito*," of which, as we understand, Maximowicz has seen a drawing only of the flowering plant, and analytical figures. It differs from other species of the genus in having ternate leaves, is 6-petalous and 6-androus: and, as the dehiscence of the anthers is not made out, the genus is quite uncertain. There is also another species from Japan, so very like our own *P. peltatum* that Maximowicz so names it, with a mark of doubt, because it has only six stamens. Formerly only our single American species was known; now we have indications of four or five East Asian and Himalayan species. Other notable plants described in this paper are such as a new *Microrhamnus* from Japan and China; and *Platypholis*, a genus from Bonin Islands near to *Conopholis.* In a review of the genus *Gleditschia*, Dr. Maximowicz shows that two Chinese species go far to invalidate *Gymnocladus*, a genus which we had supposed was most distinct. A. G.

3. *American Desmidieæ.*—*Bidragtill Amerikas Desmidie-flora*, of G. Lagerheim, is the title of a well-elaborated paper, separately issued from the Proceedings of the Royal Academy of Science of Stockholm, xlii, No. 7, published at the close of the last year. A good share of the specimens here studied and systematically enumerated are said to have been derived from the bladders of *Utriculariæ* preserved in herbaria, notably those of the Stockholm Museum and at Upsala. The author's method of preparation is detailed in the Bot. Centralblatt, xviii, No. 19, 1884. His principal habitats are Cuba, Georgia, and Tewksbury,

Mass.; the former derived from the late Charles Wright's collections, the latter from those of our old friend the late B. D. Greene, who largely collected aquatic plants in Tewksbury swamp, while the collector in Georgia seems to be unknown. A double plate contains figures of thirty species. Sixteen species are new or newly named and characterized. A. G.

4. *Notarisia.* Edited by Drs. G. B. DE TONI and DAVID LEVI. Venice, 1886.—Following the custom of mycologists in naming their journals in honor of leading mycologists, two young Venetian phycologists have started a journal to be devoted to the interests of phycology and have named it after the distinguished Italian cryptogamist, the late Professor G. de Notaris. The journal is to be issued quarterly, and the first two numbers, which have already appeared, give evidence that it will be of great service to students of Algæ. There is a summary of species of marine and fresh-water Algæ recently described, together with a review of recent papers on Algæ. The reviews and summaries are very convenient, as they present in a compact form the results of papers scattered through a large number of journals. The descriptions of species are in Latin, but it is to be regretted that the reviews are in Italian, a language which comparatively few botanists can read with accuracy. As all educated Italians can read and write French with ease, it would probably not be difficult for the editors to substitute French for Italian in their journal, a change which would be welcomed by all foreign subscribers, on whom Notarisia must depend largely for support. The journal also has some original articles of value by Lagerheim, who writes in French, and Borzi, while the editors contribute a scheme of the genera of *Florideæ* adapted to Ardissone's Phycologia. The articles are illustrated by several lithographic plates. W. G. F.

5. *Phycologia Mediterranea.* By Professor F. ARDISSONE. Varese, 1883.—Professor Ardissone, the Director of the Botanic Garden of Milan and President of the Societa Crittogamologica Italiana, published in 1883 the first volume of his Phycologia Mediterranea in the Memoirs of this Society; but it is not until recently that copies have been received in this country. It includes the *Florideæ* and *Dictyotaceæ*, and forms a large, well-printed volume of over 500 pages. The algæ of the Mediterranean have been studied by botanists of reputation for many years, but there has not hitherto appeared any work treating of them collectively. The first part of the Phycologia is all that the reputation of the author as the leading phycologist of Italy would lead one to expect. The synonymy is full, the descriptions clear and never diffuse, and the notes on distribution and microscopic structure show a wide reading and large study. It is to be hoped that Professor Ardissone will soon be able to issue a second volume including the remaining orders and thus supply the great want of a complete treatise on the marine flora of the northern coast of the Mediterranean. W. G. F.

IV. ASTRONOMY.

1. *Traité de la détermination des orbites des comètes et des planètes, par* CHEVALIER D'OPPOLZER; édition française par Ernest Pasquier. Vol. i. Paris: Gauthier-Villars. 1886. Large 8vo, pp. 491 and ccix.—The great work of d'Oppolzer is too well known to astronomers to need comment, being decidedly the most complete and satisfactory work on orbits in existence. This translation by the Louvain professor (published at his own charges) makes the work easily accessible to those to whom the French language is more familiar than the German. It is made from the second edition of the first volume of the original. The translator had the advice and assistance of the author. He has taken care to have the work, but more especially the tables, accurately printed. There have been changes both in the text and in the tables, but in the main the volume is a reproduction of the original.

This first volume is complete in itself, but it is certainly to be hoped that Professor Pasquier will be sufficiently encouraged to issue the second volume also. H. A. N.

2. *Publications of the Washburn Observatory of the University of Wisconsin.* Vol. iv, 8vo. Madison, 1886.—This volume contains several smaller articles, but the greater part of it is occupied with observations of the 303 southern fundamental stars for the zones of the *Astronomische Gesellschaft.* Of these in nearly every case six complete observations were obtained. The later observations, to complete the scheme, were made by Mr. Updegraff and Miss Lamb after Mr. Holden's appointment as President of the University of California, and are given in an appendix. H. A. N.

V. MISCELLANEOUS SCIENTIFIC INTELLIGENCE.

1. *Elisha Mitchell Scientific Society* (Raleigh, N. C.) *for the year* 1884–1885. 100 pp. 8vo.—This report opens with a sketch of the botanical work of Dr. M. A. Curtis (an obituary notice of whom, by Dr. Gray, was published in III, vol. v, 1873, of this Journal), and also a brief notice of Prof. Kerr. Among the notes in the following pages, which are mainly chemical and meteorogical, there are papers by Prof. Kerr on the distribution and character of the Eocene deposits in eastern North Carolina, and on the geology of the region about Tampa, Florida. On pp. 39, 40, Prof. F. P. Venable gives the results of analyses of the leaves of the Yopon or Ilex Cassine of North Carolina—the tree that afforded, by a steeping of the leaves, the famous "Black Drink" of the Southern Indians, which they used for medicinal (drastic) purposes. The dried leaves, collected in winter, were found to afford caffeine, 0·32 per cent. In an analysis made of leaves collected in May and dried, 0·27 per cent of caffeine was obtained, of tannin 7·39, nitrogen (on combustion) 0·73, ash 5·75; and the

ash contained in 100 parts P_2O_5 3·34, SO_3 2·50, SiO_2 1·32, Cl 0·66, Fe_2O_3 0·26, MnO_2 1·73, MgO 16·59, CaO 10·99, K_2O 27·02, Na_2O 0·47. The Maté or Brazilian Holly (Ilex Paraguayensis), according to Peckolt, affords from its dried leaves 0·639 per cent of caffeine; but the ash contained affords (as analyzed by Arate) only 2·98 of K_2O, with Na_2O 7·28, P_2O_5 5·54, SiO_2 44·75, Cl 0·71, SO_3 0·92, Fe_2O_3 3·41, MnO_2 2·50, MgO 11·39, CaO 12·34.

2. *Report on the work of the International Geological Congress.*—Dr. Frazer states to the Editor of this Journal that in his report, noticed on page 403, there are two typographical errors: on page 41, 16th line, Bergakademic should be Bergakademie; and page 44, 2d line, J^2 should be J ?.

3. *National Academy of Sciences.*—The following are the titles of the papers entered to be read before the Academy at the session of April, 1886, at Washington:

H. A. NEWTON: The Comet of Biela.

H. A. ROWLAND: On the absolute and relative wave lengths of the lines of the Solar Spectrum.

IRA REMSEN: Influence of Magnetism on Chemical Action.

WOLCOTT GIBBS: Platinous compounds as additive molecules.

S. P. LANGLEY: On the Invisible Spectra.

A. W. WRIGHT: Crystallization of Platinum by means of the electric discharge in vacuo;—Effect of Magnetization on the Electrical resistance of metals.

A. M. MAYER: On the diathermancy of Ebonite and Obsidian, and on the production of Calorescence by means of Screens of Ebonite and Obsidian;—On the Coefficient of Expansion of Ebonite;—On the determination of the Cubical Expansion of a solid by a method which does not require calibration of vessels, weighings or linear measure;—On measures of absolute Radiation.

OGDEN N. ROOD: On color contrast.

R. E. PEARY, U. S. N.: On a proposed Expedition into the interior of Greenland during the present summer with Disco as a base. (By invitation.)

ELIAS LOOMIS: Areas of High Barometric Pressure over Europe and Asia.

G. K. GILBERT: The Geologic Age of the Equus Fauna.

T. STERRY HUNT: The Cowles Electrial Furnace.

G. F. BECKER: Cretaceous metamorphic rocks of California. (By invitation.)

CHAS. D. WALCOTT: Classification of the Cambrian System of North America. (By invitation.)

E. D. COPE: On the Geology of the region near Zacualtipan, Hidalgo, Mexico; —On the Phylogeny of the Batrachia;—On the Phylogeny of the Placental Mammalia.

S. H. SCUDDER: The Cockroach in the past and in the present.

THEO. GILL: The ordinal and super-ordinal groups of Fishes.

W. K. BROOKS: The Stomatopoda of the "Challenger" collection;—Budding in the Tunicata.

EDWARD S. MORSE: On ancient and modern methods of arrow release.

ALEXANDER GRAHAM BELL: Upon the Deaf and Dumb of Martha's Vineyard (continuation of Research relating to the ancestry of the Deaf).

4. *The Library* of the late Professor Guyot is offered for sale by Mr. E. Sandoz, of Princeton, N. J. It is rich in works in the departments of General and Physical Geography, and in scientific publications of all kinds, including maps. The number of vols is about 4000, and of pamphlets and periodicals about 3000. The price per volume is $1.20, and for the pamphlets and periodicals 10 cents each.

5. *S. W. Ford's article*, p. 466, fig. 1 is enlarged 5 times, and fig. 2, nearly 3.

OBITUARY.

Charles Upham Shepard.—Professor Shepard died, after a short illness, on the first of May last, at Charleston, S. C., where for many years he had spent his winters. He was born in Little Compton, R. I., in the summer of 1804, and hence had nearly completed his eighty-second year. But until his last illness he was still young in his ardent devotion to his favorite science, his delight over the rare and beautiful among minerals, whether in his own cabinet or that of another, and his zeal for collecting and discovering new facts and new species; and not less young in his cheerful and kindly nature.

After graduating at Amherst College in 1824, he became a student of Professor Nuttall's at Cambridge in Botany and Mineralogy, and soon after engaged at Boston in instruction in these branches. At the same time he commenced his publications on mineral localities and their minerals, in this Journal.

In 1827, Mr. Shepard accepted the position of assistant to Professor Silliman in Chemistry, Mineralogy and Geology, which he retained, to the great satisfaction of the Professor, for four years. While thus engaged he also continued, during leisure weeks, his field and laboratory work in mineralogy. "A Mineralogical Journey in Northern New England," including a study of the remarkable localities of Acworth, N. H., and Paris, Me., and "The Mineralogy and Geology of Orange County, N. Y., and Sussex County, N. J.," illustrated by a detailed map of the various, mineral localities, are the titles of two of the many papers published by him at that time; and they indicate his desire to give others a knowledge of localities, as well as to make known the results of his investigations.

In 1832, Professor Shepard published the first part of a "Treatise on Mineralogy," in which the system of the eminent Austrian mineralogist, Mohs, was adopted as to nomenclature and as to the natural history idea of mineral species. The second or descriptive part of the work, containing the descriptions of the species arranged in alphabetical order, appeared in 1835. This delay in its publication was partly owing to Professor Shepard's acceptance, from the general government, for the winter of 1832–33, of an appointment as an associate with Professor Silliman, for the investigation of the methods of sugar culture and manufacture in the Southern States, and to the preparation of his report on the subject, which was incorporated with that of Professor Silliman made in 1833 to the Secretary of the Treasury. In the same year, 1835, he joined Dr. Percival by appointment from the State legislature, in the Geological Survey of Connecticut; and two years later, in 1837, appeared his excellent report on the mineralogy and mineral products of the State.

His professorial work after 1832 was divided between New Haven, Conn., Amherst, Mass., and Charleston, S. C. To his duties at Yale under Professor Silliman were added those of Lecturer in Natural History, which position he held for fifteen years.

From 1845 to 1852, and from 1861 to 1877, he occupied the chair of Chemistry and Natural History in Amherst College. In 1854, he was called to the Professorship of Chemistry in the South Carolina Medical College at Charleston; he continued there until 1861, and again resumed the duties of the chair in 1865, after the civil war, resigning them finally in 1869, when his son, Charles U. Shepard, Jr., was appointed his successor.

These university engagements interrupted but little his mineralogical work. His first new species, microlite, was announced in this Journal in 1835, Warwickite in 1838, and Danburite in 1839. Other discoveries followed these, occasionally of new species, often of kinds not before identified on the continent.

Professor Shepard's private collection of minerals, under so great personal activity, became large and choice, surpassing all others on the continent. On retiring from his professorship at Amherst the whole was purchased by Amherst College. Unfortunately it passed from under his care to a building that was not fire-proof, and one night in 1880 it was nearly all destroyed. Professor Shepard did not cease collecting when he and his cabinet parted; but with his old zeal redoubled by the sight of empty shelves and drawers, he soon had again a large collection; and it continued to increase and to grow in interest with him to the close of his life.

Professor Shepard early commenced also the collection and study of meteorites, and through his life these shared with minerals in his affections and his labors. In 1829, nearly sixty years since, his first paper on the subject was published in this Journal; and others followed, until the number reached nearly forty, the series closing with one in the last volume (September, 1885). His collection grew, each paper being usually based on one or more acquisitions; and it was long the largest in the country. It became like the minerals, and with them, the property of Amherst College.

Dr. Shepard's zeal to the end knew no flagging, and he had the satisfaction of seeing great progress in his two departments, that of meteorites and that of minerals, through his labors. His knowledge of mineral species was unsurpassed in the land; and he was hence ready with quick judgments as to new and old; sometimes too quick—but in any case imparting progress to American Mineralogy.

Dr. Shepard was several times in Europe and had the personal acquaintance of many European mineralogists. He was a member of various American and Foreign societies; among them, the Imperial Society of Naturalists of St. Petersburg, and the Royal Society of Göttingen. He was a man of refinement and great courtesy, and was held in very high esteem in Charleston, S. C., as well as at his northern homes. His place of residence since leaving Amherst, and for much of his life before, was New Haven. He leaves two children, a son and a daughter.

INDEX* TO VOLUME XXXI.

* This Index contains the general heads BOTANY, CHEMISTRY, GEOLOGY, MINERALS, OBITUARY, ROCKS, ZOOLOGY, and under each the titles of articles referring thereto are mentioned.

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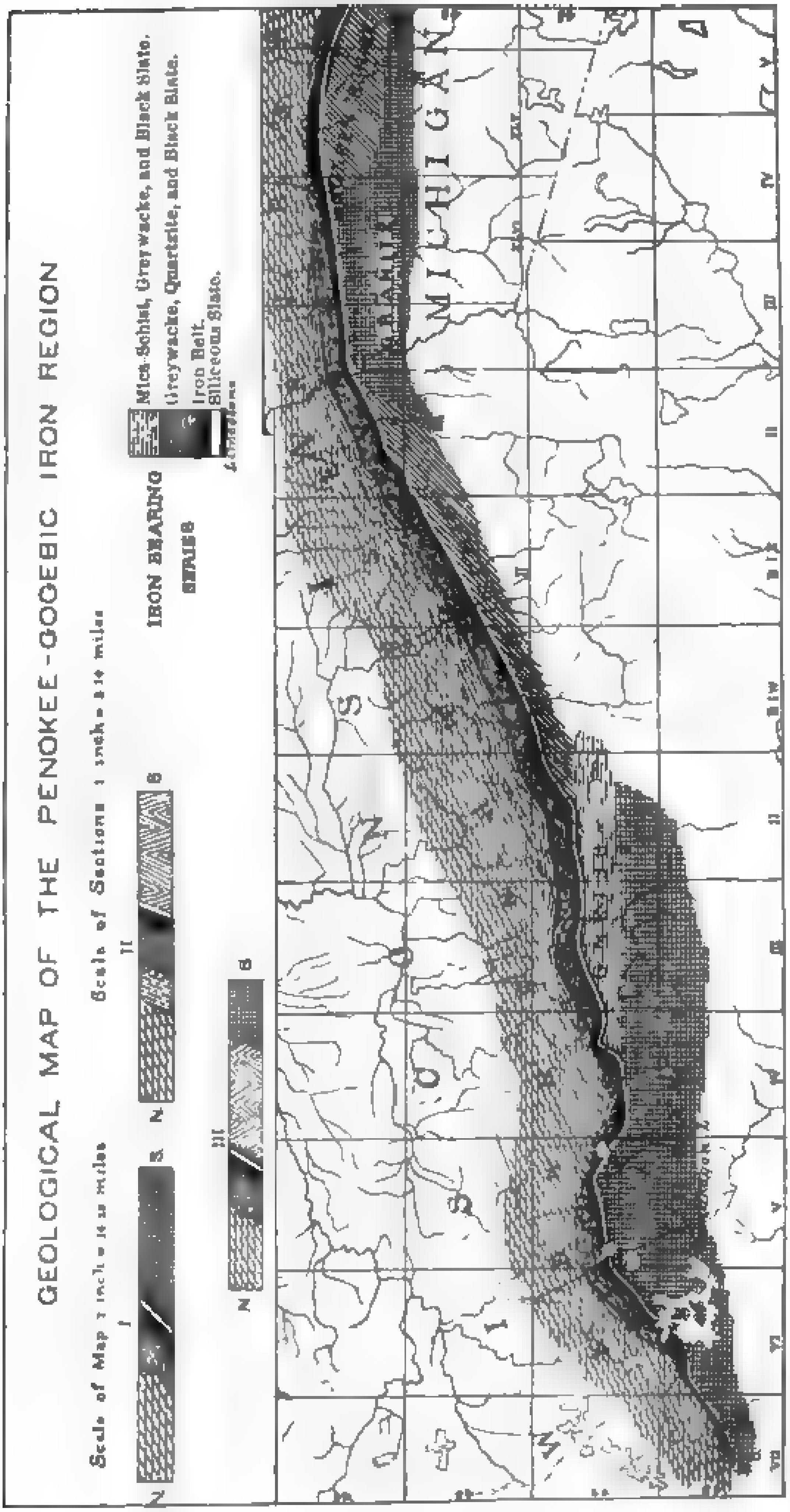
GEOLOGICAL MAP OF THE PENOKEE-GOGEBIC IRON REGION
Scale of Map
Scale of Sections
IRON BEARING STRATA
Mica-Schist, Greywacke, and Black Slate.
Greywacke, Quartzite, and Black Slate.
Iron Belt.
Siliceous Slate.
Limestone.
MICHIGAN